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270 VOLT DIRECT CURRENT

GENERATING SYSTEM

DESIGN, DEVELOPMENT AND TEST

FINAL REPORT

APPROVED FOR PUBLIC RELEASE; DISTRIBUTION

UNLIMITED



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LUCAS AEROSPACE
POWER EQUIPMENT CORPORATION
777 LENA DRIVE
AURORA, OHIO 44202

AUGUST, 1991

Prepared For
Naval Air Systems Command
Department of the Navy
Washington, D.C. 20361-0001

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<p>This report details the design and PFRT (Preflight rating test) results of a 45KW 270V D.C. generating system designed to the requirements of NADC specification NADC-60-TS-7803 dated 5 January, 1978.</p>					
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1.0

INTRODUCTION

This report details the design and pre-flight testing of a 45 kw, 270 volts d.c., 9000-18000 rpm, brushless, conduction oil-cooled generator and associated system control and protection unit (GCU).

The effort was undertaken under contract to the U.S. Navy, Air Vehicle and Crew Systems Technology Department. The design and performance objectives were in accordance with U.S. Navy specification NADC-60-TS-7803 dated 5 January, 1978.

The primary objective of the development was to demonstrate the practicability of producing a wide speed range generator operating in a 270 volt d-c system capable of meeting transient and ripple voltage requirements.

2.0

SYSTEM DESCRIPTION

The 45 kw, 270 volts d.c. Generating system consists of:

<u>Description</u>	<u>Model No.</u>	<u>Unit Weight, Pounds</u>
45 kw, 270 volts d.c., brushless, conduction oil- cooled generator (with integrated oil supply; pump, filter, etc.)	30527-000.	72.00
Generator Control Unit	51527-000	5.75
Current Sensor	50527-000	1.70

The system is designed to the requirements of NADC specification NADC-60-TS-7803. The system is designed for normal operation in the following configurations and for change from any one of these configurations to the other in flight or on the ground:

- a) Parallel operation of two, three, or four generators. (Only the two generator parallel system was demonstrated as part of this program.)
- b) Operation of the generators and their associated load busses as isolated systems.
- c) Any combination of parallel and isolated channels compatible with the bus and generator arrangement.

The system control diagram is shown on drawing 51527-250. This drawing provides a logic function diagram for the generator control unit illustrating the

operation of all control and protective functions as well as the SOSTEL interface.

The generator is a two bearing, oil-lubricated, conduction oil-cooled machine with two, three-phase stator windings, phase shifted 30° and full-wave rectified with two bridges connected in parallel through an interphase transformer. A three phase permanent magnet generator provides power for excitation and control functions. The generator includes an inter-neutral transformer that is used for diode failure detection, feeder fault detection, paralleling control, and current limiting. Also included are two overtemperature switches which provide stator overtemperature warning followed by activation of an automatic mechanical disconnect at a higher temperature.

The generator control unit is a convection self-cooled unit that contains the voltage regulator, control and protection circuits for coordinated system performance under both normal and abnormal system conditions, and the generator system interface to accommodate status interrogation by the SOSTEL power management system. Control power for operation of system power contactors is also provided from the GCU.

The voltage regulator, a pulse width modulated type, provides control of the generator exciter field current to maintain constant voltage at the point of regulation. Paralleling control provides equal load sharing between two or more generators operating in parallel. Current limiting is also provided to limit the overload current to 150 percent of rated load.

Protective functions provided for the system include overvoltage, undervoltage, overexcitation, underexcitation, feeder fault, faulted (open or shorted) generator output rectifier, excessive ripple and differential voltage. In addition to the voltage regulator, paralleling, current limiting, and system control power, control functions include a generator control relay and line contactor control.

The GCU provides eight SOSTEL channels for each generator system. Two channels provide system and generator thermal status information for power management and maintenance storage. The remaining six channels, one for each protective function, provides maintenance information as to which protective function actuated to trip the generator channel due to abnormal conditions.

The current sensor is designed to be installed on the positive generator output feeder and provides a d-c output voltage that is proportional to the magnitude of the current in the feeder. A similar device is installed in the negative return in the generator and the two current signals are used to detect feeder faults by sensing the differential between sensors. The generator sensor also provides the signal for current limiting and for load sharing during parallel operation.

The equipment is designed to have a useful life of not less than 15 years under any combination of operating and storage conditions. The generator has a calculated thermal life which indicates it will exceed 10,000 hours while the generator control unit and current sensor exceed the required 20,000 hours.

The system is designed to provide its rated output at the point-of-regulation (POR) over the generator input speed range of 9,000 to 18,000 RPM. The system is also capable of delivering 125 percent rated current for a minimum of two minutes and 150 percent rated fault current for a minimum of 7 seconds. The generator is sized to include a 10 volt feeder drop between the generator and the POR at rated system load.

The generator voltage regulator will regulate the steady state voltage to the limits shown when operated over the rated speed range of 9,000 to 18,000 RPM:

	<u>Load</u>	<u>Regulation</u>
a.	Loads between minimum and rated load	270 ± 5 volts
b.	Loads between rated and 125 percent of rated load	270 ± 10 volts

The output voltage will also remain within the limits shown when the generator is driven at 19,800 RPM overspeed with minimum electrical load applied.

Because of the nature of a rectified a-c generator, a minimum load must be defined when specifying performance parameters such as regulation, transient recovery and ripple. At generator loads below this minimum value, voltage modulation occurs because of an inability of the generator output filter capacitor to discharge faster than it can be recharged. The voltage modulation causes no damage or degradation to the generator or regulator and is not seen on the load bus, but it does make the measurement of output voltage meaningless. The minimum load defined for this generator system is 5.0 amperes, which is provided by a bleeder resistor external to the generator.

To ensure that the system will be electromagnetically compatible, the following precautions have been taken in the design of the generator, generator control unit and system interwiring with a view to minimizing electromagnetic interference:

- a) Circuit designs provide for minimum noise generation and susceptibility.
- b) Interference-free components were used.
- c) Circuits and components that may have adversely affected one another, were isolated and separated.
- d) Components within a circuit function were grouped together to minimize wire lengths between components.
- e) Ground returns were carefully routed within circuits and between circuits to minimize stray coupling and ground loops.

- f) Enclosures were designed to ensure proper mating of interface surfaces and radiation shielding.
- g) Shielded ground pins are provided in the connector for grounding aircraft wire shields to chassis ground.

The conduction oil-cooled generator has no enclosure openings and provides low impedance bonding to the drive gearbox. Filter capacitors are connected across the parallel bridge output.

The switching voltage regulator and switching-type regulated power supplies are the principal sources of electromagnetic interference in the GCU. Control of switching speeds is used to minimize noise generated by these sources. Shielding of the PMG and exciter field wires will be required to minimize radiated emissions as a result of voltage regulator switching. A separate connector pin is provided for each aircraft wire shield to ground the shield to the equipment chassis inside the unit. All externally exposed metal parts are grounded to their respective chassis by providing good conductivity across the mounting surface.

The CMOS integrated circuit devices that are used extensively in the GCU have an inherent high noise immunity and susceptibility is not considered to be a problem area.

An important element in the reduction of radiated interference (emission and susceptibility) is the design of the equipment enclosure. An ideal shield would have extremely high conductivity, great thickness, high permeability, and is virtually watertight with no openings or discontinuities. A practical shield represents compromises dictated by weight and space limitations. Therefore, the GCU enclosure is a deep drawn aluminum structure with a single overlapping cover resulting in a minimum number of openings.

Proper grounding is another significant factor in providing noise immunity. Each circuit board is carefully designed with separate ground returns as required to ensure that ground loops within circuits are avoided.

System integral control power is derived from the permanent magnet generator (PMG) located in the generator. The PMG is a three phase ungrounded power source which is electrically independent from all other power sources. This supply is rectified within the GCU and at that point the GCU establishes the ground reference for the system integral control power. For grounding purposes, a control power return, separate from the main system ground, is made available through a pin of the operational connector on the GCU.

Drawing 51527-250 describes the system logic and control of the system. The system is designed for single or parallel operation. A single pole three position switch provides for cockpit control. With the switch in the "ON" position, build up and connection to the load bus and fault protection are automatic. No source of power other than that provided by the generator PMG is required.

As the engine is started, PMG power increases proportionately. At a speed of approximately 5,500 RPM, sufficient voltage is available from the PMG for all control and protection circuits to become active; however, the generator control relay (GCR) will not close until the underspeed circuit picks up at approximately 8,000 RPM. When the GCR closes, the generator will be energized. As the underspeed circuit picks up and the GCR is closed, the inhibit on the undervoltage time delay is removed and the start-up control switch from the underspeed circuit to the GCR control is locked out.

As the generator voltage builds up, the undervoltage circuit will pick up. The line contactor control circuit will provide a "close" signal to the line contactor when the generator voltage is within 5 volts of the bus voltage. If the bus tie contactor is closed, the equalizer relay in the GCU will be energized as the line contactor closes and connect the parallel control circuit to the equalizer bus. The system is now operating normally supplying power to the load bus or busses operating as a single generator or in parallel with other operating generators. All protective circuits are active and SOSTEL interrogation will provide a normal indication.

Shutdown of the system can be accomplished by placing the generator control switch to the "Off-Reset" position. This acts to deenergize the generator by opening the generator control relay (GCR), which in turn will open the line contactor to disconnect the system from the load bus. SOSTEL interrogation will indicate normal since no fault signals are present.

The other form of normal shutdown occurs on engine shutdown with the generator control switch "ON". For this condition, an underspeed signal at approximately 8,000 RPM will result in a GCR trip signal after a 2 to 3 second delay. However, the GCR latch circuit is not triggered. As the GCR opens to deenergize the generator, the line contactor is also opened to disconnect the system from the load bus.

This operation deviates from the specification requirements and the following is the rationale for using it:

- 1) To prevent a single wire failure from resulting in a sustained generator full-field condition, undervoltage protection is used to deenergize the generator in addition to disconnecting it from the load bus. An open voltage sensing wire will result in a system overvoltage, but appear as an undervoltage to the GCU.
- 2) Using the undervoltage to trip the GCR, underspeed inhibits this function during normal start-up or shutdown to prevent a nuisance "lock-out", which would require a manual cycling of the generator control switch to reset the system. This inhibit also prevents false fault indications. In addition, there is no advantage to having the generator energized at speeds below the minimum speed for regulation. A 2 to 3 second time delay was selected to prevent nuisance tripping due to normal underspeed transients.

During normal operation if any of the following faults occur, the generator will be deenergized (latched) and disconnected from the bus and a "trip" signal indicated to SOSTEL:

Feeder fault.

Shorted main rectifier (0.3 - 0.5 second delay).

Undervoltage/Underexcitation (5 - 7 second delay).

Overvoltage/Overexcitation (inverse time delay).

Overcurrent (7 - 10 second delay).

The following faults will trip (latch) the line contactor and provide a field indication for SOSTEL:

Open main rectifier (5 - 7 second delay).

Excessive ripple (5 - 7 second delay).

The following paragraphs describe briefly each protective function. The generator control unit design and function are described in detail later in this report.

Feeder Fault

Current sensors located on the positive feeder and in the generator negative return provide voltage signals proportional to the magnitude of the current. If the negative signal exceeds the positive signal by more than 35% of the rated generator current, a trip signal is applied to a bi-stable flip-flop, which in turn trips the GCR and disconnects the generator from the load bus.

Shorted Rectifier

A shorted main rectifier is detected by a combination of signals. An inter-neutral transformer senses the ripple voltage existing between the displaced stator windings and also a large increase in amplitude that is accompanied by an increase in the field current ripple. This results in a trip signal after a 0.3 - 0.5 second time delay which deenergizes the generator and disconnects it from the load bus.

Undervoltage/Underexcitation

An undervoltage condition (or underexcitation) during parallel operation that is not accompanied by an underspeed signal trips the bi-stable latch circuit after a 5 - 7 second delay and thus trips the GCR to deenergize the generator and disconnect it from the load bus.

Overvoltage/Overexcitation

An overvoltage (or overexcitation) condition during parallel operation triggers an inverse time delay which in turn triggers the bi-stable latch circuit to trip the GCR and line contactor.

Overcurrent

The current limit circuit acts on the regulator to limit generator output current to 150% of rating. As this threshold is exceeded, the circuit triggers a 7 - 10 second time delay which in turn acts to trip and latch the GCR and trip the line contactor.

Open Rectifier and Excessive Ripple

The inter-neutral signal from the generator and a normal field current ripple signal indicate an open main rectifier for either single generator or parallel operation. Excessive ripple (greater than 12 volts peak-to-peak) of the generator output voltage may be indicative of a failed output filter. These functions trigger a 5 - 7 second time delay circuit which in turn triggers a bi-stable latch circuit that trips the line contactor, but does not deenergize the generator. A "fault" indication is provided for SOSTEL. The generator is maintained in a stand-by status and will be automatically connected to the load bus if the remaining generator systems are lost or shutdown.

False Trip

All protective circuitry is designed to prevent the possibility of tripping for faults other than those for which the protection is intended. Tripping will not occur during normal system operation, i.e. during system buildup, load switching transients, normal input speed changes, etc. The design also considers the possible effects of susceptibility to conducted and radiated electromagnetic interference (EMI) as well as switching relay transients.

3.0 GENERATOR DESCRIPTION

3.1 Electrical Design

The electrical part of the generator consists of three major components: the main generator, the exciter, and the permanent magnet generator (PMG). In addition, vital segments of the electrical design are the output rectifier bridge, interphase transformer and filter capacitors.

The main generator stator and rotor consist of laminated structures assembled from cobalt-iron alloy laminations.

The stator core is wound with an asymmetrical, 6-phase wye-connected winding. In effect, this winding is two, separated, 3-phase windings displaced from one another by 30 electrical degrees. Each of the two windings is connected to a full-wave rectifier bridge. The two output bridges are connected

in parallel separated by an interphase transformer. The transformer absorbs at any instant the voltage difference between the two bridges and thereby ensures 120 degree conduction and balanced load sharing by each of the 12 output rectifiers. This winding - rectifier arrangement yields a 12 pulse system of rectification (ripple frequency is 12 times fundamental, i.e. rotational frequency) and minimum voltage ripple. Construction details and component ratings of the output bridges are discussed further in the Mechanical Design section of this report.

A non-salient pole, six-pole, distributed field winding configuration was chosen in preference to a salient-pole with concentrated field coils. This was done for structural integrity because support of the windings and the lamination geometry itself minimize concentrated areas of high stresses. In addition, cooling of the windings is improved because resistance losses are more uniformly distributed around the rotor periphery.

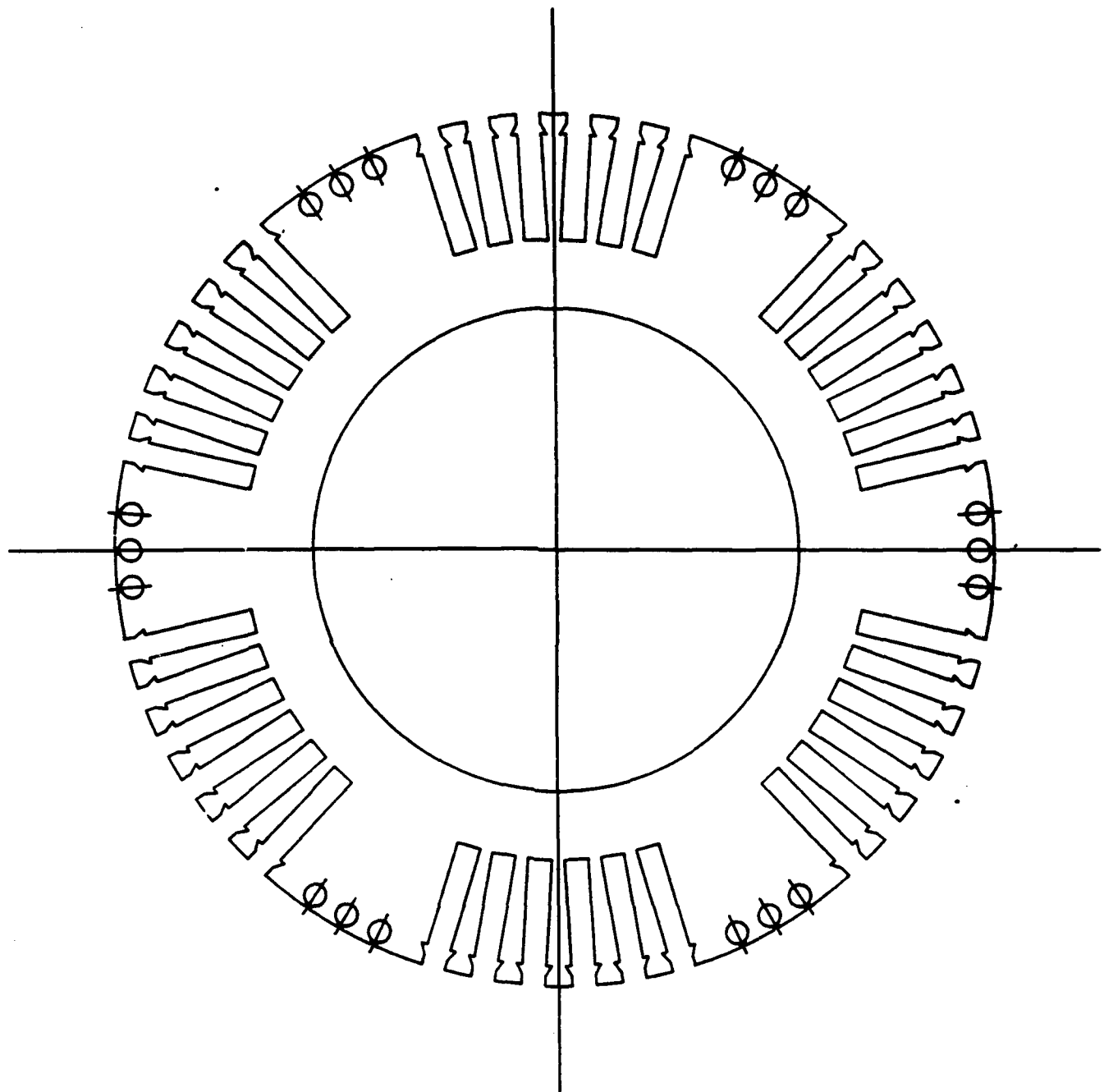
The main field winding is of rectangular magnet wire and held securely in slots. The winding is distributed around the rotor periphery. The number of slots is chosen to yield a sinusoidal distribution of air gap flux density.

In the usual aircraft type of a-c generator, the salient pole configuration is used. A "squirrel-cage" damper winding is contained in slots in the pole-head. This winding ensures stability with parallel operation and minimizes the effects of the negative sequence field produced with load unbalance. In the non-salient pole, distributed field winding type of generator, the conductive rotor slot wedges are used as the damper winding and usually no damper winding, per se, is used.

The LAPEC model 30527-000 generator employs beryllium-copper alloy rotor slot wedges. Initially, this approach was deemed adequate for an appropriate damper winding circuit. During the course of development testing it was found that with a relatively high value of capacitance shunting the load, the output voltage would modulate severely. This instability would appear and disappear depending on generator speed and the magnitude of output load current. To solve this stability problem, the main generator rotor design was changed to include a squirrel-cage damper winding (similar to that in salient pole machines). Slots are punched in the pole-centers and round copper bars placed in these slots. These bars are connected on each end by brazing to copper end laminations. A representation of the rotor lamination geometry is shown on Figure 3-1. The additional damper circuit totally eliminated all tendencies toward instability.

Excitation power for the main generator field is supplied from a three-phase exciter whose output is rectified to d.c. by a three-phase, full-wave bridge. The design of the exciter generator is coordinated with the excitation requirements of the main generator and voltage regulator control. Silicon steel laminations are used in the stationary field and rotating AC armature of the exciter, since the weight-size saving of cobalt-iron alloy does not justify the resulting cost increase in the exciter configuration.

FIGURE 3-1
ROTOR LAMINATION



The permanent magnet generator (PMG) is designed to provide integral control power suitable to meet all the system requirements. This includes power for generator excitation through the voltage regulator, control power needs and external system requirements. The PMG is both air and short circuit stabilized for consistent and stable operation. In order to keep the length of the rotor (and the generator) to a minimum, as well as provide a ring-band-supported casting for the Alnico VI magnet structure, the PMG is designed as an "inside out" design with the rotating magnet on the outside of, and surrounding, the stationary wound stator.

The output of the PMG is tapped off to a full-wave rectifier bridge arrangement to supply power to the generator-mounted disconnect solenoid. When the generator's main stator end turn overtemperature switch is closed by an overtemperature condition, the power from this bridge energizes the disconnect solenoid, thus activating the mechanical disconnect mechanism, and appropriately conditions the SOSTEL resistance interface. The electrical schematic diagram on the generator outline drawing 305270000 shows the circuitry.

TABLE 3-1

LAPEC GENERATOR
MODEL 30527-000
ELECTRICAL PERFORMANCE CHARACTERISTICS

Rating (continuous)	45 kw
Overload (2 min.)	56.25 kw
Overload (7 sec.)	67.5 kw

RATED VOLTAGE

P.O.R.	270 volts d.c
Gen. Term.	280 volts d.c.

SPEED

Normal	16,000 rpm
Range	9,000 to 18,000 rpm
Overspeed	19,800 rpm
Proofspeed (Qualification)	21,600 rpm

EFFICIENCY

(Calculated)	87.6%
--------------	-------

3.2

Mechanical Design

The generator consists of two sections, the oil supply adapter section and the generator section. The oil supply adapter shall hereafter be referred to as the adapter.

3.2.1

Adapter

The adapter has the generator proper mounted to it. In turn, it mounts the resulting adapter-generator assembly to the engine drive gearbox. It houses the generator integral cooling oil supply components which are described in greater detail in the following paragraphs. The adapter and its mounting relationship to the generator proper is shown on the outline drawing (305270000/0001 in the appendix. A "cutaway" drawing showing the generator/adapter's internal construction can also be found in the appendix.

The adapter housing is an A357-T7 aluminum sand casting with suitable ports, oil passages, etc. to accommodate and provide for the cooling oil supply requirements. The configuration may be best understood by viewing the generator outline drawing found in the appendix.

The mechanical disconnect is composed of a worm gear and a plunger driven worm sector. The worm gear is splined to the adapter main shaft and is axially engaged, through mating jaw teeth, to the adapter input drive shaft. The plunger-mounted worm sector is retracted and cocked in the normal operating mode and held in this position by an electrical solenoid-actuated locking pin. Should an extreme overheat condition occur within the generator, a stator end-turn mounted thermal switch will close and the solenoid will be energized thus retracting the plunger locking pin. The spring-loaded plunger will then be released and will drive its worm sector into engagement with the rotating worm gear, thus axially retracting the worm gear. This in turn, will immediately separate the driving axial jaw teeth previously described and stop the adapter main shaft rotation and consequently that of the generator rotor. The input shaft will continue to rotate and will be retained in the drive gearbox spline. The disconnect splines are normally running in the oil within the adapter housing which serves as the oil system oil sump. Therefore, the disconnect mechanism and the drive shaft are well lubricated in the normal mode, and in the disconnect mode as well if loss of oil is not the cause of overheat. Should a loss of oil, however, be the cause, residual oil and oil vapor at the input drive shaft's supporting ball bearing will provide sufficient lubrication until flight's end and corrective action is taken. Once the automatic disconnect is initiated, the SOSTEL interface is made aware of the condition. The stator's thermal switch condition is sensed by the GCU through the generator electrical connector and the proper SOSTEL interfacing is accomplished by the GCU. See the generator outline drawing in the Appendix for a review of the electrical schematic.

A reset of the mechanical disconnect mechanism can only be made on the ground by manually retracting the disconnect plunger handle and re-latching the solenoid's spring-loaded locking pin.

The adapter also houses the oil system main pump and main feed pump as shown on the generator outline drawing. The pump elements are positioned in tandem and are driven on a common internal shaft by means of a gear in engagement with a gear on the adapter main shaft.

The purpose of the main pump is to circulate the generator's self-contained oil through the aircraft-provided oil cooler and through the generator to cool it. the purpose of the main feed pump is to ensure a positive oil feed to the inlet of the main pump, particularly for sustained operation (at least 1 minute) in inverted flight. A schematic of the oil flow scheme may be seen on the generator outline drawing.

The input drive shaft conforms to the MS3334 accessory design standard and has a readily replaced drive spline sleeve. It is supported in the adapter by a ball bearing at one end and by the centering, disconnect drive jaw coupling at the other. The drive shaft incorporates a shear section designed to prevent disengagement of the O-ring packing from its drive gland in the event of a shear section failure. In the event of a shaft shear failure any oil leakage from the generator to the drive-adapter interface cavity drain should be minimal since the adapter pumps will cease to be driven.

Some of the adapter additional hydraulic components are listed below with a brief description. Their place in the cooling oil hydraulic circuit can best be seen by the hydraulic schematic shown on the generator outline drawing.

Starting from the discharge of the main pump, the components are:

- a) The pressure regulator valve is of a sleeve valve arrangement. It is insensitive to any particle contamination. It bypasses the intended oil oversupply (for pressure regulation) of the main pump back to the oil sump at the maximum rated speed of the generator.
- b) The case pressurizing aspirator uses the main pump bypass regulating flow to aspirate external air into the adapter case to prevent cavitation at the pump's oil inlet port.
- c) A case pressure relief valve is provided to prevent excessive case pressures.
- d) The vacuum relief and air filter valve gives entrance to aspirated air drawn into the case by the aspirator assembly and at cool down by contraction of the generator/adapter's contained air.
- e) A 40 micron oil filter is provided to filter the main pump discharge oil flow to the external cooler. An integral bypass valve is provided for cold start-ups and to prevent unjustified "pressure drop" indications.
- f) The oil filter assembly incorporates a "pressure drop" pop-out indicator to indicate a clogged oil filter condition.

- g) An anti-drain valve is used as a simple check valve in the oil circuit from the cooler to prevent cooler oil drainage back into the adapter case.
- h) A self-closing, magnetic drain plug of the bayonet (quick disconnect) type is used to check for magnetic particle contamination and to provide for drainage of the adapter oil sump. The plug is snapped out by a push and turn motion without the benefit of any tools and is not lockwired. The valve closes and the magnetic plug is exposed for visual inspection.
- i) A quick-disconnect pressure fill coupling is used. It has a full-grip locking device to fully engage the pressure fill mating part. It is readily coupled or uncoupled without special tools.
- j) A port for gravity oil fill is provided.
- k) Inlet and outlet ports are provided for hydraulic line connections to the external oil cooler. Stainless steel inserts are used to provide solid, wear and thread-stripping resistance for these connections.
- l) An oil level sight gage is provided in the location shown on the generator outline drawing.

3.2.2

Generator

The generator housing is made of an A357-T61 aluminum heat treated sand casting. It is mounted to the adapter by means of studs and self-locking nuts through a sturdy flange.

The generator's cooling oil passages are drilled to eliminate cooling passage coring in the casting. The housing walls are sized to withstand the hydraulic pressures of the cooling oil and the housing-to-stator shrink fit.

A containment calculation was made to assess the kinetic energy absorption capability of the generator main stator and housing. Calculating the kinetic energy of the rotor at the 21,600 rpm proofspeed condition as 1,761,060 in-lbs and the strain-energy absorption of the generator main stator and housing at 3,802,571 in-lbs, the containment requirement should be met even without taking an impact factor into account.

The generator housing also mounts the main output rectifier bridge, its output filtering capacitors, the output load sensor, the main terminal block, and the generator/gcu interfacing connector. Various aspects of the housing are covered in more detail in the following paragraphs.

The main stator consists of cobalt-iron alloy laminations axially welded across the outer periphery. Also welded axially across the outer periphery in four shallow slots are four straps extending beyond the end of the stack to enable the stator to be solidly bolted to the housing as well as being shrink-fitted to the generator housing oil passage sleeve.

Firmly attached and epoxy bonded to the stator winding end turns are two thermal switches. One is normally closed, which, when thermally opened, will indicate a precautionary, or "fault" overtemperature condition. The other normally open switch when thermally closed will energize the adapter's disconnect solenoid and cause an immediate disconnect of the generator from the drive.

The steel rotor shaft is of a large diameter, hollow, welded construction to provide a lightweight stiff structure. The main field core is shrink-fitted to the oil cooled main rotor shaft, for good heat transfer and drive over the generator's speed range. The exciter rotor assembly is piloted and bolted to the main rotor shaft for ease of assembly/disassembly. The PMG rotor is a close fit within the exciter rotor's cup-like support assembly to which it is keyed and axially retained by a beveled snap ring.

The rotor is supported by oil lubricated ball bearings at the ends of the rotor. The span between the rotor's bearings is relatively short. This, coupled with the large diameter of the rotor shaft, results in a rotor critical speed well above the generator's 21,600 rpm proofspeed.

The exciter stator laminations are riveted together, ground on the outside diameter and encased in a steel liner. The steel liner permits solid bolting of the exciter stator to the housing. It also prevents any buckling of the stack due to circumferential loads induced by the housing-to-stack differential contraction at low temperatures. The exciter stator (field) windings are machine wound on nylon bobbins encircling the exciter stator's poles

The exciter rotor is of conventional construction, except that its lamination's inside diameter was reduced to produce a section thicker than would be required for magnetic purposes. This was done to reduce the lamination bore stresses at the relatively high maximum operating speeds. Hoop-like bands are used over the rotor's winding end turns to constrain them over the generator's speed range.

The PMG stator is positioned within its rotor magnet bore rather than vice-versa in the conventional fashion. This "inside-out" configuration was configured in this manner to provide a compact, short generator because the entire PMG is packaged within the exciter section. The stator is firmly piloted and bolted to the generator housing. The PMG stator windings are connected to the generator electrical connector for transmission of power to the GCU. The windings are also tapped for rectification by a generator-mounted full-wave bridge circuit to provide self-contained power to energize the generator's disconnect solenoid. The circuitry is shown on the generator outline drawing.

The PMG rotor magnet is a cast Alnico, salient-pole type of an "inside-out" configuration. This means that it has poles protruding within its bore rather than from its outside diameter in the conventional manner. This arrangement permitted mounting the PMG section within the bore of the encompassing exciter rotor section resulting in a compact mounting arrangement.

The main field excitation diodes are housed within the rotor in the position most favorable position to withstand the 14,253g rotational "g" loads experienced at 18,000 rpm. Ceramic encased diode suppression resistors are used across the diodes for transient voltage spike suppression purposes. They too are well supported to resist the centrifugal "g" loads.

Electrical connections from the exciter rotor are made directly to the terminal ends of the diodes. They are directed radially inward through the exciter rotor support, supported by it, and the ends bolted to the diode terminal ends.

The diodes are electrically insulated from their mounting to the rotor shaft by means of thin, high temperature, polyimide insulation material. Cooling oil flowing through the rotor shaft cools the diodes by means of conduction to the oil.

Connections from the rotating diodes to the rotor main field are made through well-insulated plus and minus copper straps to the rotor-mounted diode output bridge. The diode output bridge connections are pre-wired prior to the insertion and mounting of the diodes within the exciter-rotor support.

The generator's oil-cooled bearings are of a full ball complement, HDB-105 size, and, have a bronze retainer configuration. They were qualified on the generator for the F-15 program and have given excellent service. Not one bearing failure has been experienced to date on the F-15 program or during the development of this 270 HVDC generator. Although the F-15 generator's rated speed is 12,000 rpm, this kind of bearing's "DN" value (the product of bore diameter in millimeters and rpm) exceeds 1.5 million. If this figure is used, then the limiting speed based on a 1.5×10^6 DN for this application is 60,000 rpm. This safely exceeds this generator's maximum operating speed of 18,000 rpm and also its 21,600 rpm proof speed by a significant margin.

Because the generator is conduction oil-cooled, three rotating oil seals are required; one at the adapter input shaft which must seal against the adapter's low case pressure, and one at each end of the rotor to seal against the cooling oil system pressure.

Spring-loaded, carbonface oil seals were ultimately used. Their stationary sealing rings are carbon rings with faces lapped to within two helium light bands. The rotating mating rings are also lapped to within two helium light bands. The stationary seal case is press-fitted in the housing and the mating ring is clamped and O-ring sealed to the rotor shaft. The static O-ring seals used are fluorocarbon, high temperature, compression set resistant, "O-rings" per MIL-R-83248.

The main output rectifier bridge is composed of three heat sink-diode assemblies. The largest of the three is the "negative" of the generator output, and it mounts six of the 12 output diodes. The other two smaller heat sinks make up the "positive" output portion of the bridge. They each mount three diodes comprising the remaining 6 diodes of the 12 diode array. The two

positive heat sinks are connected to the interphase transformer as shown on the electrical schematic on the generator outline drawing.

Both the positive and negative heat sinks are made of an aluminum extrusion with an internal passage for oil cooling. The heat sinks are electrically insulated from the generator housing in accordance with the specification requirements. Positive and negative output leads are bolted to the heat sink and the terminal block mounting terminal studs with suitable lugs. Cooling oil is pumped through the heat sinks to conduction cool the main output diodes.

A capacitor array is connected across the output bridge for output power conditioning.

The output diodes are rated for a PIV of 1,200 volts and a current per cell of 72 amperes at a case temperature of 138°C. The average current required per diode for 1.0 PU, 1.25 PU, and 1.5 PU loads based on a 45 KW output are 27.8, 34.7 and 41.7, amps respectively.

A molded terminal block is provided on the end of the generator as shown on the generator outline drawing. Large stud-type terminals provide for surface to surface contact between the generator output conductors and the feeder leads. To "key" the output terminals in order to prevent misconnections, one stud (B+) is of a 1/2 inch diameter and the other (E-) is of a 3/8 inch diameter. A protective cover (not shown on the generator outline drawing) is provided.

A connector conforming to MIL-C-83723, Class H, Series 3 is provided on the generator to make the necessary connections to the GCU. Although only 12 pins are required, a M83723-79H1624N (#16 shell size) connector with 24 pins is used. This permits wider spacing of the pins to provide better pin-to-pin dielectric voltage resistance.

Conduction oil-cooling of the generator was chosen in order to avoid high windage and churning losses that could exist were spray oil-cooling to be used for a generator of this size at the 18,000 rpm max. operating speed, 19,800 rpm overspeed and 21,600 rpm proofspeed. The cooling oil management system is described by the cooling oil circuit shown on the generator outline drawing.

An oil flow is approximately 4.0 gpm (gallons per minute). The additional flow from the main circulating pump is by-passed to the sump at the 18,000 rpm operating speed by the adapter pressure regulating valve. This flow (approx. 3.5) gpm is adequate for an external oil cooler.

Stress analyses were made for the rotating components, that is, the main rotor, the exciter rotor, and the PMG rotor. The results of these stress analyses and the stress limits of the applicable components are listed in Table 3-2.

TABLE 3-2
BORE STRESSES - PSI

<u>Speed</u>	<u>Main Rotor*</u>	<u>Exciter**</u>	<u>PMG***</u>
9,000	8,686	7,593	3,735
16,000	27,453	23,997	11,804
18,000	34,745	30,371	14,939
19,800	42,041	36,749	18,076
21,600	50,033	43,735	21,513

*Stress yield point of cobalt-iron alloy is 55,000 PSI

** Stress yield point of lamination steel is 51,000 PSI

*** Tensile strength of Alnico is 23,000 PSI

Generator Weight and Overhung Moment

Model: 30527-000

Weight: 72.0 lbs. (dry)

Overhung Moment: 451.9 in-lbs (dry)

As noted above, the eventually developed generator came in over the specification weight of 52.0 lbs. and the LAPEC proposal weight of 58.0 lbs. The generator's overhung moment, however, was within the proposal's 456 in-lb. value and the specification's 550 in-lb. limit. There are a number of reasons for the generator's overweight condition. One was the result of a significant computer error in calculating the weight of the generator's main stator. Another was the post-proposal change in the generator's design. An envisioned weight reduced design turned out to be an overzealous one which could not be realized. Also, it is believed that the specification weight of 52 lbs. which could be considered realistic for a 45 KW rated generator alone at its nominal, 16,000 rpm speed, is not realistic for a 9,000 rpm minimum speed design with an integral oil supply adapter with its reservoir, pump, disconnect, filter, etc.

Materials and Processes Selections

Materials and processes used in the manufacture of the generator are listed on Table 3-3.

These materials and processes were selected to meet the environmental and corrosion resistance requirements during the life of the generator in accordance with the specification.

TABLE 3-3

MATERIAL AND PROCESS SELECTIONS
270 HVDC GENERATOR

Part Name	Material	Material Specification	Heat Treat	Processing and Finish	Inspection	Notes
Generator Housing	Aluminum Alloy	MIL-A-21180 Alloy A357-T61 Grade C, Class 2	None	Chem Film MIL-C-5541, 1 coat TT-P-1757 Primer plus 2 coats TT-E-489, FED-STD-595 enamel color wht. No. 17875	MIL-C-6021	LAPEC 16-023005 Method I
Generator Shaft Components	Alloy Steel Tubing	MIL-T-6736 (AISI 4130)	Nitride MIL-S-6090	---	MIL-I-6868	Inspect per LAPEC 99-500001
Shaft Spline Inserts	Alloy, Steel	AMS-6274 (SAE 8620)	Nitride MIL-S-6090	---	---	---
PMG Rotor	Permanent Magnet	Alnico 6	N/A	---	---	LAPEC 15-016208
Molded Coil Bobbin (Exciter)	Glass Reinforced Nylon 6/6	L-P-395 Type II Grade A	N/A	---	---	---
Arc welding (TIG) Generator Shaft	---	---	N/A	MIL-W-8611 Class B-1	---	LAPEC PS-1700

TABLE 3-3

MATERIAL AND PROCESS SELECTIONS
270 HVDC GENERATOR

Part Name	Material	Material Specification	Heat Treat	Processing and Finish	Inspection	Notes
Electrical Connection Brazing	Silver Brazing Alloy	Silver Alloy QQ-S-561	N/A	MIL-B-7883	---	---
Arc Welding TIG Laminated Stack	---	---	N/A	MIL-W-8611	---	---
PMG Stator Laminations	Silicon Steel	AISI Type M-22 LAPEC 15-016203	Magnetic Anneal LAPEC 16-011002	---	---	---
Main Stator Laminations	Iron-Cobalt Vanadium Alloy (Hipercro 50)	LAPEC 15-016209	Magnetic Anneal LAPEC 16-011011	---	---	---
Non-Structural Hardware	Carbon Steel Bar	QQ-S-634 Comp. 1018/1020	---	Treat per TT-C-490, Type I (For Varnish Adhesion)	---	Treat per LAPEC 16-023015
Exciter & PMG Rotor Support	Aluminum or Alloy 2024	---	Heat Treated	---	---	---

TABLE 3-3

MATERIAL AND PROCESS SELECTIONS
270 HVDC GENERATOR

Part Name	Material	Material Specification	Heat Treat	Processing and Finish	Inspection	Notes
Exciter Stator Stack Rivets	Carbon Steel	QQ-W-405 Comp. 1006/1010	None	---	---	---
End-Turn Support Exciter Rotor	Stainless Steel Tubing (304)	MIL-T-5695 1/4 Hard	None	---	---	---
End-Turn Support Band Main Rotor	Stainless Steel Tubing (Custom 455)	AMS 5617	Solution Heat Treated Precipitation Hardened at 1,050°F.	---	---	---
Bus Strip, Diode Assy.	6063-T6 Aluminum Alloy Extrusion	QQ-A-200/9 Condition T-6	Solution Heat Treated and Aged	Chem Film MIL-C-5541	---	---
Static Seal "O" Ring	Fluorocarbon Elastomer	MIL-R-83248 Type I, Class I	N/A	---	---	---
Generator Terminal Block	Diallyl Phthalate, Fiberglass Reinforced	MIL-M-14 Type GDI-30F	N/A	---	---	---

Material	Material Description	Material Specification	Material Grade	Material Supplier	Material Part Number	Material Drawing
Impregnate	Diphenyl Oxide Resin	TT-P-1757	N/A	---	---	---
Fastener Anti-Corrosion Compound	Zinc Chromate Paste	---	N/A	---	---	LAPEC 05-651002
Anodizing Aluminum Alloys	---	---	N/A	---	---	LAPEC 16-023013
Soldering Electrical Connections (Diodes)	Tin-Lead Solder	QQ-S-571 Type SB-5	N/A	---	---	LAPEC 16-018003
Chem Filming Aluminum Alloys	---	---	N/A	---	---	LAPEC 16-023005 Method I
Passivation of Stainless Steels	---	---	N/A	---	---	LAPEC 16-023005 Method I
Magnet Wire	Polyimide Film Insulated Cooper Wire	MIL-W-583 Type M2	N/A	---	---	LAPEC 15-038273 Rectangular LAPEC 15-038272 Round
Electrical Insulation, Sheet	Aromatic Polyamide	MIL-I-24204	N/A	---	---	LAPEC 15-014028
Electrical Insulation Filmtape	Polyimide Film (Kapton)	MIL-P-46112, Type I (W/Adhesive)	N/A	---	---	LSI 15-543204
Electrical Insulation, Sheet	Kapton/Nomex/Kapton Laminates	MIL-P-46112 and MIL-I-24204	N/A	---	---	LSI 15-014029

Material	Material Description	Material Specification	Material Grade	Material Supplier	Material Part Number	Material Drawing
Impregnate	Diphenyl Oxide Resin	TT-P-1757	N/A	---	---	---
Fastener Anti-Corrosion Compound	Zinc Chromate Paste	---	N/A	---	---	LAPEC 05-651002
Anodizing Aluminum Alloys	---	---	N/A	---	---	LAPEC 16-023013
Soldering Electrical Connections (Diodes)	Tin-Lead Solder	QQ-S-571 Type SB-5	N/A	---	---	LAPEC 16-018003
Chem Filming Aluminum Alloys	---	---	N/A	---	---	LAPEC 16-023005 Method I
Passivation of Stainless Steels	---	---	N/A	---	---	LAPEC 16-023005 Method I
Magnet Wire	Polyimide Film Insulated Cooper Wire	MIL-W-583 Type M2	N/A	---	---	LAPEC 15-038273 Rectangular LAPEC 15-038272 Round
Electrical Insulation, Sheet	Aromatic Polyamide	MIL-I-24204	N/A	---	---	LAPEC 15-014028
Electrical Insulation Filmtape	Polyimide Film (Kapton)	MIL-P-46112, Type I (W/Adhesive)	N/A	---	---	LSI 15-543204
Electrical Insulation, Sheet	Kapton/Nomex/Kapton Laminates	MIL-P-46112 and MIL-I-24204	N/A	---	---	LSI 15-014029

4.0 CONTROLS DESCRIPTION

4.1 Generator Control Unit

The 51527-000 generator control unit GCU is designed to the requirements of specification NADC-60-TS-7803/2 for controlling a 270 volt d-c generator in either a single or paralleled multi-generator system.

In addition to providing control for a generator in a single and up to a four generator paralleled system, the GCU provides the protection functions to insure that the channel is operating properly. In the event of a failure, the generator is deenergized, removed from the load bus and the channel trip status is presented to the SOSTEL power management system.

A detailed description of the operation of each of the circuit functions shown on logic diagram 51527-200 follows. The circuits discussed are in the order of control functions, protective functions and SOSTEL interface circuits.

Power Supplies

The unit accepts high voltage three phase power from the permanent magnet generator and converts it for use in powering the main generator exciter field, a regulated high voltage auxiliary power supply, and the low voltage control circuits within the GCU. The main generator exciter field supply is regulated at 270 volts. The high voltage is used in order to minimize the number of stages of power conversion and the supply is regulated so that stable generator control can be maintained under conditions of high speed and light generator loads. High voltage NPN transistors connected as a Darlington pair form the heart of the switching regulator which is powered by the PMG rectifier bridge. In order to avoid the need of a high voltage PNP driver transistor for the Darlington pair, a separate floating driver supply is formed from an auxiliary winding of the step down transformer used for 28 volt control power. This lower voltage rated PNP transistor which, in turn, is driven from the 28 volt control logic.

The 270 volt, 0.5 ampere auxiliary supply is powered from the same switching regulator used to provide the 270 volt exciter field power supply. In order to maintain a good quality of power on the auxiliary supply, it is diode isolated and separately filtered. The voltage transients due to field current switching are thus prevented from appearing on the auxiliary supply. A diode isolated 270 volt output for bus tie contactor control is powered from this auxiliary supply.

The 28 volt DC control power for the GCU is provided by a step down transformer and a low voltage switching regulator. The switching regulator is used because of the large range of PMG voltage which is produced over the 2:1 generator speed range. In addition to the use of the 28 volt power supply by the internal GCU control circuits, the voltage is supplied to the generator control switch, the line contactor and bus tie contactor auxiliary contacts, and the current sensing current transformers. In the event of an overload (greater than one ampere) or a short circuit on this supply, current limiting is employed

to protect GCU internal components. An additional 15 volt supply is provided for the single sided operation of comparators, operational amplifiers, and logic circuits.

Voltage Regulator

The voltage regulator circuitry is essentially the same design as that which LAPEC supplies to Boeing on the ALCM program, a 28 volt rectified system. Two operational amplifier stages within the regulator provide for the proper input voltage compensating network and exciter field current feedback, both of which are essential for stabilizing the control loop and providing optimized response, especially when controlling a generator over a large speed range. The best choice of a compensation network and value of exciter field current feedback was determined by computer modeling of the control loop as well as laboratory testing. The various generator constants for this linearized model are determined from the generator design curves at no load and high speed, the most critical condition for stability. Since it is desirable that a single regulator circuit be used to control machines with different ratings, and therefore, different characteristic parameters, this modeling was useful in predicting the effect that the varying parameters have on the system response.

The rest of the regulator consists of a high pass filter, for the ripple, which produces pulse width modulation at the output of the summing and voltage comparison amplifier. This pulse width modulation signal is used to drive the current amplifier which controls the current flowing in the generator exciter field. A free wheeling diode is provided across the field of the machine to maintain constant current flow when the transistors switch off. A high voltage NPN transistor (Darlington) is used in switching the field current. The PNP driver transistor in this configuration is tied to the 28 volt supply, thereby eliminating the need for a high voltage device. A low value sensing resistor on the emitter of the field driver transistor is used to feed back a signal proportional to the magnitude of field current to the voltage regulator, thereby stabilizing the control loop.

This type of control circuitry is characterized by smooth and stable transitions from "full on" or 100 percent duty cycle down to less than 5 percent duty cycle. These conditions may be found from minimum load to full load over the wide speed range of the machine. As mentioned previously, the field power supply itself is regulated, this being done to put a limit on the voltage available to the field at high generator speeds. Unstable operation would otherwise occur because the high PMG voltage would result in a high regulator gain, at the same time that the high speed results in a high gain in the exciter.

Another consideration for stable operation at light load is voltage modulation caused by the inability of the generator filter capacitor to discharge, a problem not encountered in a conventional brush-type machine. Based upon a ratio from past experience, the minimum load should be approximately 5.0 amperes. This minimum load is a permanently connected load.

The range of adjustment of the regulated voltage is from 255 volts to 290 volts. This adjustment is made by removing the top cover and turning the potentiometer with a flat blade screw driver. The potentiometer changes the regulated voltage by varying the reference which is presented to the voltage regulator.

Paralleling Control

The signal from the current sensor in the generator neutral leg is used by the paralleling control to cause the load to be shared equally by all of the generators tied to the load bus. The paralleling control senses the voltage difference between the equalizer bus and the current sensor signal to determine load sharing. If the equalizer bus voltage is greater than the local generator load current signal, this indicates that other generators are carrying more of the load than the local generator, then the paralleling control biases the voltage regulator circuit to supply more excitation to the local generator. A large time constant is used with this circuit to avoid unstable operation or load swapping.

The equalizer relay, KEQ, is used to prevent one GCU from trying to share load with a second GCU which is not on line. The KEQ relay is energized, connecting the GCU to the equalizer bus only when the line contactor and the bus tie contactors are closed.

Current Limiting

The current limiting circuit serves to limit the generator output current by lowering the regulated output voltage during periods of heavy load. At 1.5 times rated generator load, the voltage from the current sensing transformer within the generator exceeds a threshold value and the current limit circuit lowers the voltage regulator reference voltage. Since the current sensing transformer within the generator is sized to the generator rating, the same threshold voltage may be used within the GCU when controlling generators of various ratings.

A second threshold sensing circuit is used to start a timer, which after 7 to 10 seconds, results in a fault condition. Whenever current limiting has operated for this length of time, the reason is determined to be a bus fault condition that has not cleared, and the generator is deenergized and disconnected from the load bus in order to prevent generator damage.

Line Contactor Control

The line contactor control circuit provides 270 volt, 100 milliampere power from the regulated auxiliary supply to power the coil of the line contactor. Power is applied to the output pin by means of high voltage PNP Darlington transistors, rated for a collector voltage of greater than 400 volts. The transistors are driven by a high voltage NPN transistor which in turn is powered from the low voltage control logic gates. The operation of the logic circuitry has been described in the start up and shut down of the system description and not repeated here.

The differential voltage sensing is used to inhibit the closing of the line contactor until the POR voltage rises to within 5 volts of the bus voltage during build up. A differential comparator is used to provide this function. Since the difference voltage disappears once the line contactor is closed, this function is effective only during initial build up.

Field Relay Control

The field relay (GCR) provides for the safe and sure deenergization of the generator exciter field in the event that a failure condition has been recognized. An electromechanical, rather than a semi-conductor device was chosen for this function to insure that if an unexpected environmental condition exists which caused the failure of the field transistor, the same condition would not cause the failure of the device used for protection. The relay is a SPDT vacuum type, rated for 3 amperes at 2,500 volts, and 15 amperes at 300 volts. This gives adequate safety margin when considering that a maximum voltage supplied by the partially loaded PMG is 700 volts at high speed, and the field current at this voltage in a "full on" condition, is only 2.6 amperes.

Since the operation of the logic circuitry controlling the GCR was explained in the "system description", it is not repeated here. Note that the control circuitry does turn off the field circuit prior to the opening of the relay during normal operation, thereby eliminating unnecessary electrical contact wear.

Overvoltage/Overexcitation Protection

Overvoltage protection is used to prevent excessive voltage from appearing on the load bus in the event of a control failure. The POR voltage is sensed and compared to a reference which is independent of the voltage regulator reference. Once the sensed voltage exceeds 290 volts, the output of an integrator begins to ramp upward at a rate determined by the amount of overvoltage. When the voltage reaches a set level, the generator control relay is tripped, and the line contactor is opened. In this method, an inverse time curve of overvoltage is produced, which not only insures that allowable bus voltage versus time limits are not exceeded, but also prevents nuisance tripping due to unusual, but temporary, voltage transients. Because the POR sensing wire is used for both control and protection functions, an unsensed failure could result if this wire were opened. In this eventuality, the voltage regulator would falsely sense zero voltage and cause the field to turn full on, but at the same time OV protection would be lost. For this reason, the undervoltage sensing, which would sense this failure, is able to cause a generator control relay trip, deenergizing the generator and opening the line contactor.

During parallel generator operation, the overexcitation protection is used to selectively trip a failed channel, even though an overvoltage may not be present on the load bus. This is accomplished by using the output of the paralleling control to bias the overvoltage protection circuit to a lower threshold voltage. If the voltage regulator fails to respond to the paralleling control command to lower regulated voltage due to current hogging by the local generator, the

condition is recognized as an overexcitation of the local generator, and a trip of the generator control relay results.

Undervoltage and Underexcitation Protection

Undervoltage (U.V.) protection is used to insure that a voltage less than 240 ± 5 volts is not maintained on the generator output for more than 5-7 seconds. The POR voltage is sensed and compared to a threshold voltage, and if the voltage is below the U.V. limit, and the generator control relay is closed and the system is up to normal operating speed, a timer is started. If the condition does not correct itself before the time is completed, the GCR is tripped and the line contactor is opened.

Underspeed

Underspeed sensing is used by the GCU to determine true failure conditions and, in addition, to automatically shut the channel off during engine coast down. One phase of the low voltage PMG waveform is squared and sensed by a pulse width discriminator circuit to determine the condition of generator speed. A PMG frequency below 800 Hz, which corresponds to a generator speed of 8,000 RPM, is defined as an underspeed condition.

Feeder Fault Protection

In order to sense a fault which occurs between the generator and the line contactor, two d-c current sensing transformers are used. The current sensors, which are described in Section 4.2, provide a d-c voltage proportional to the current flowing thru them. One sensor is provided close to the generator, in the generator neutral leg. A second sensor is mounted near the line contactor or the point of regulation. A current flowing through one of the sensors, but not the other is a fault current and this is detected as a voltage difference between the sensor outputs. A window comparator circuit is used to determine when the fault current reaches 63 ± 5 amperes which is the feeder fault trip point. The fault condition causes the generator to be deenergized and the line contactor to be opened.

Failed Generator Rectifier Protection

The failed generator rectifier protection circuit is used to monitor the generator output rectifiers and to determine either an open or shorted rectifier condition. The open rectifier condition is considered to be a less serious failure, and if needed the generator still able to provide rated load continuously. Therefore, a generator with an open rectifier is placed on stand-by in the event that subsequent failures in other generators require the reinstatement of the first generator. The information of whether each generator is supplying current to the load is provided by auxiliary contacts on the line contactor and bus tie contactor. If both contacts are closed, the generator is "on line" and this information is provided to each of the other GCU's in a paralleled system. With the present design, when up to four generators are paralleled, each will receive

the information on the status of the other three. More generators could be easily accommodated by this system should this be necessary.

The sensing of a shorted rectifier results in a trip of the generator control relay within 0.3 to 0.5 seconds. In this case, the generator is deenergized and the line contactor is opened.

Excessive Voltage Ripple Protection

An excessive voltage ripple circuit is used to determine the condition of the generator output voltage. If a failure, such as an open generator filter capacitor, should cause ripple in excess of 12 volts in either polarity on the generator output, the same action is taken as previously described for an open generator rectifier failure. The stand-by condition is again maintained unless the operation of the generator is required.

To accomplish this protection, the peak type filter circuit very similar to that described for the rectifier failure detection circuit, is used. The excessive ripple detection feature will work well with an isolated generator, but when operating paralleled generators, a failure such as an open filter capacitor is hidden by the action of the paralleled generator.

SOSTEL Interface

In order to report the condition of the various protection features of the generator control system, a series of resistances are switched into and out of the SOSTEL interrogation path. In each case except one, logic gates are used to drive optical isolators which perform the resistor switching. The optical isolators are used because the relationship of the SOSTEL interface ground and the GCU control logic ground is not known. The one exception to the optical isolator output is the generator thermal status. Under normal conditions, $720 \pm 10\%$ ohms are found across this output. If an overtemperature condition occurs within the generator, thermostat opens, raising the resistance across the output to $1100 \pm 10\%$ ohms. This is to be interpreted as a precautionary or fault condition. In the event that a mechanical disconnect occurs, a contact closure changes the resistance to $420 \pm 10\%$ ohms, the trip condition.

The system status is similarly reported to SOSTEL. In this case, a fault condition is presented only by the identification of an open generator rectifier or of excessive generator ripple voltage. This is the precautionary or stand by condition for the system. Each of the other failures produce a trip indication on this output. For the purpose of identifying which failure has caused a trip or a fault indication, the following protective functions are provided to the SOSTEL interface:

Open Rectifier	Overexcitation/Underexcitation
Shorted Rectifier	Overvoltage
Feeder Fault	Overcurrent
Undervoltage	Ripple Voltage

Either the normal (720 ohm) impedance or the trip (420 ohm) impedance is presented at each of these outputs.

Design and Construction

The outline of the generator control unit is shown on drawing 515270000. The package is designed to conform to the envelope dimensions and mounting requirements of specification NADC-60-TS-7803/2.

The electrical and physical design of the unit is made so that dependable performance is provided under any of the expected environmental conditions. The details of the design are discussed in the following paragraphs.

The generator control unit is constructed using a one piece formed aluminum base with the physically large and high heat dissipating components mounted directly to it. This chassis not only provides a secure mounting for components such as the circular connectors and the power transformer, but also provides a good thermal path for the power transistors and the transformer. Those components tied directly to high voltages are also mounted on the chassis wherever possible. The remaining electronic circuitry is contained on three horizontally mounted printed wiring boards above the chassis. The printed wiring boards are connected to the chassis components thru pin and socket type board connectors, which are mounted across the front face of the unit behind the circular connectors. These printed wiring boards are easily removed for servicing by removing the tie down screws at the rear of the unit. Circuit board guides along the length of the package provide additional support for the boards. This entire assembly is protected from the external environment by a deep drawn aluminum top cover and a flat aluminum bottom cover. Access to the voltage adjustment potentiometer is made from the back of the unit, after removing the top cover. Since in-service adjustment is not required, easy external access to it is not provided.

Electrical connections are made through each of the two circular connectors on the front of the unit, as shown on the outline drawing. All of the control system interconnections are made by means of the larger connector, numbered M83723-72R2255N, while the SOSTEL power management interface is made by the M83723-72R1212N connector. In providing a conservative design, a number of pins in the control connector are left vacant. Those pins adjacent to the three high voltage PMG input pins are not used in order to provide adequate pin-to-pin dielectric voltage isolation. This connector features 25% spare pins. The choice of SOSTEL system connector provides only one spare pin for future use.

The GCU is designed to operate in the maximum ambient temperature without depending upon heat conduction through the mounting feet. Heat is dissipated from the surface of the unit by natural convection and radiation. The design is also made to minimize the heat that is generated by using low power logic circuits and multiple transistor stages in high voltage switches.

Electrical Design

The generator control unit circuitry consists basically of digital MOS devices to perform the control and protection logic functions. High voltage switching is accomplished with NPN silicon junction transistors because these devices are readily available with voltage ratings greater than required for this design.

The design utilizes components which are readily available. Generous derating factors for component parameters are employed to insure reliable operation under sustained operation at the environmental extremes. The use of low power CMOS logic not only reduces the GCU internal temperature rise increasing the predicted reliability, but also provides for noise insensitive operation. Threshold levels for transistor switches are maintained at a high level to complement the noise rejection.

4.2

Current Sensor

The 50527-000 current sensor provides a d-c output voltage that is proportional to the current in the cable passing through the window opening of the sensor. The sensor uses a magnetic core with two magnetoresistors installed in the core air gap. The magnetoresistors (MR) are semiconductor devices that exhibit an increase in resistance as a function of an applied magnetic field. The MR devices are connected in a simple bridge circuit that will be unbalanced by the resistance change resulting from an increase in the flux density in the core as the cable current increases. The error signal from the bridge is amplified and drives a transistor connected as an emitter follower. This transistor provides a d-c current in a bucking winding on the core to re-establish bridge balance. The current in the winding will be directly proportional to the current in the cable (generator output) and thus produces an output voltage signal.

A stabilized permalloy alloy magnetic core is used to provide the magnetic field for the flux responsive magnetoresistor (MR) devices that are installed in the air gap. Two magnetoresistors have been used to compensate for the relatively high temperature coefficient of the devices, and the MRs are selected for matching resistance characteristics. The MRs are procured mounted on a thin silicon steel substrate and are epoxy bonded to the surface of the core in the air gap.

The core is potted into a metal can base assembly and small wiring board is installed above the core on stand offs and contains the remainder of the bridge circuit resistors, amplifier networks and driver transistor.

The sensor requires 28 volts input excitation voltage to provide 0 to 5 volts output voltage.

The 505270000 is designed for base-plate mounting with connector on the front provided for electrical connections. The feed through aperture provides a well radiused entry and exit to prevent cable chafing, and has a 0.75 inch diameter opening which will accommodate the required cabling.

Drawing 505270000 shows the general configurations and the outline dimensions of the current sensor.

The current sensor is a purchased item -- not a LAPEC product.

5.0

PREFLIGHT RATING TESTS AND RESULTS

In accordance with Navy specification NADC-60-TS-7803, preflight rating tests were performed on a single system and two parallel systems. A system comprises the model 30527-000 generator, Model 51527-000 generator control unit (GCU), and two Model 50527-000 current sensors.

In April, 1984, the contract was amended to delete the following specified tests:

Heat rejection and efficiency
Mounting position
Performance and endurance (50 hours)

In addition, "Dielectric Strength", was waived in November 1988.

These deletions and waivers were requested and granted with a view to expediting completion of the test program.

The following tests were performed:

<u>Test</u>	<u>Specification Reference</u>	<u>Page</u>
5.1 Examination of Product	4.6.1	36
5.2 Overload	4.6.4	37
5.3 Voltage Regulation	4.6.7, 4.6.11, 4.6.12.4	38
5.4 Voltage Ripple	4.6.10	40
5.5 Short Circuit Capacity	4.6.9	38
5.6 Paralleling	4.6.12.1	41
5.7 Shutdown	4.6.12.2	43
5.8 Parallel Load Division	4.6.12.3	44
5.9 Overvoltage Function Trip	4.6.12.5	45
5.10 Undervoltage Function Trip	4.6.12.6	47
5.11 Protection Performance	4.6.14	50

Tests were performed under the following conditions:

Ambient temperature: 77 +/- 27 degrees Fahrenheit.

Ambient pressure: Sea level

Mounting: The generator was mounted with longitudinal axis horizontal;

generator control unit and current sensor assemblies were also mounted with their bases horizontal.

Voltage measurement: System voltage was measured at the point-of-regulation (POR).

Feeders: The feeders were sized to ensure a maximum voltage drop of 10 volts at rated current (167 amperes).

Generator Speed: Depending on the nature of a particular test, the generator was operated over its speed range of 9,000 to 18,000 rpm. Rated average speed is 16,000 rpm.

Excitation: The generator is self-excited and controlled by the GCU.

Warm-up: Prior to functional tests, the system (or systems) operated at rated conditions until components reached stabilized temperatures. Temperature stabilization is reached when the rate of change of temperature does not exceed four degrees Fahrenheit in one hour.

During the functional tests, the following measurements were made:

- Output voltage and current
- Excitation current
- Ambient temperature
- Generator windings and housing temperatures
- Inlet and exit oil temperatures
- Oil pressures and flow rate
- Generator speed

Thermocouples were installed on the generator to measure the winding, housing, and oil temperatures.

Instrumentation for the individual tests was chosen from the list shown on Table 5-1. All electrical meters and temperature indicators used had been calibrated at their normal specified interval. If a test duration were to exceed the specified interval, calibration was done prior to start of the test. Power supplies, drive stands and similar equipment are not subject to a specified calibration schedule. These equipment items are used in conjunction with calibrated instrumentation. Other items not subject to specified calibration intervals have been calibrated by the respective manufacturer or have been used for "coarse" readings only prior to final adjustment or readings with calibrated equipment.

The accuracies of instruments used for the principal measurements are:

- Speed: ± 50 rpm
- Current: ± 1.0 percent
- Voltage: ± 1.0 percent
- Temperature: ± 4 degrees Fahrenheit

Data was recorded on LAPEC standard test data sheets and, in some cases, on oscillographic traces.

TABLE 5-1

INSTRUMENT IDENTIFICATION LIST

<u>Item</u>	<u>Manufacturer</u>	<u>Model No.</u>	<u>Range</u>	<u>Accuracy</u>
Oscilloscope	Tektronix	2246	-----	Manufacturer's Manual
Multimeter	Fluke	8600A	0-1200 volts	DC \pm (0.02% RDG + 0.008% F.S.) AC, (0.2% RDG + 0.04% F
Measurement Plotting System	Hewlett Packard	7090A	0-100 volts	0.15%
DC Ammeter	Weston	901	0-1/2/5 AMPS	0.5% F.S.
DC Ammeter	Weston	931	0-100/200/500 AMPS	0.5% F.S.
DC Ammeter	Weston	430	0-500 AMPS	
DC Voltmeter	Weston	901	0-150/300/750 Volts	0.5% F.S.
DC Voltmeter	Weston	901	0-3/150/300 Volts	0.5% F.S.
Temperature Indicator	Instrulab	2000 Data Logger	0-150 to 1600°F 0-50 Volts DC	\pm 0.5°F \pm 0.05% DC
Frequency Conditioner	Daytronic	3240A	0-1000 Hz	\pm 0.05% F.S.
Frequency Conditioner	Daytronic	3240	0-1000 Hz	\pm 0.05% F.S.
Load Bank	Avtron	K593	0-to-400 AMPS IN STEPS 270 Volts DC	

TABLE 5-1
INSTRUMENT IDENTIFICATION LIST

<u>Item</u>	<u>Manufacturer</u>	<u>Model No.</u>	<u>Range</u>	<u>Accuracy</u>
Multimeter	Fluke	25	0-1000 Volts	0.1% DC
Drive Stand	Lucas/PEC	No.: 5	0-35000 RPM	\pm 50 RPM
Drive Stand	Lucas/PEC	No.: 6	0-35000 RPM	\pm 50 RPM
Multimeter	Fluke	8840A	0-2000 Volts AC/DC	0.5% AC/DC
Counter/Timer	Anadex	CF-635R	0-99999 Counts	\pm 1.0 Count
Shunt	Weston	----	500 AMPS to 50 Mv	0.5% F.S.

5.1

Examination of Product

Purpose: The purpose of these examinations are to ensure that the generator, GCU and current sensor met their respective dimensional requirements in accordance with their respective outline drawings.

Procedure: Measurements were made by a qualified representative of LAPEC Q.A. department on two generators, two GCU's, and one current sensor. Results were recorded on standard LAPEC documented layout reports.

Results: Documented layout reports are included in succeeding pages of this report.

Discussion of results: The generators met all of the dimensional requirements but weights exceeded the specification value. A discussion of generator weight has been included in section 3.2 Mechanical Design.

Both GCU's inspected had dimensional discrepancies and exceeded the specification weight of 5 pounds. The dimensional discrepancies are acceptable in view of the fact that both units are prototype (laboratory) units. The increased weights of the unit resulted from modifications required following design verification testing. Based on today's technology, the GCU specification weight and dimensions can be met.

Lucas Aerospace

Lucas Aerospace Power Equipment Corporation

DOCUMENTED LAYOUT REPORT

Vendor/Dept. No.

534/902

Part No.

30527-000

Dwg Issue

C

Drawn By

54807

EWI
R. B. 100

21498

Name

GENERATOR

Qty. Rec'd

1

Inspector

LES

Date Rec'd

6-7-1988

ITEM NO.	PRINT DIMEN.	TOLERANCE	ACTUAL DIMEN	ACC	REJ	REMARKS
1	13.06 DIM.	MAX.	12.9350	✓		
2	6.88 DIM.	MAX.	6.860	✓		
3	6.805 DIM.	MAX.	6.792	✓		
4	7.44 DIM.	MAX.	7.374	✓		
5	6.88 RAD	MAX.	6.810	✓		
6	6.19 RAD	MAX.	6.050	✓		
7						
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25						

Disposition

1

2

3

4

5

6

APPR REJECTED

Supervisor

Date

Signed

Engineer

Date

Lucas Aerospace Power Equipment Corporation DOCUMENTED LAYOUT REPORT

Vendor/Dept. No. 902
 EWO 54807 EWE 26498
 Qty. Rec'd 1 Inspector LESQ
 Date Rec'd 7-19-88 (15 355)

Part No. 30527-0000 Dwg. Issue C
 Name GENERATOR
 #101

ITEM NO.	PRINT DIMEN.	TOLERANCE	ACTUAL DIMEN.	ACC	REJ	REMARKS
1	13.06 DIM.	MAX.	12.962	✓		
2	6.88 DIM.	MAX	6.870	✓		
3	6.805 DIM.	MAX.	6.798	✓		
4	7.44 DIM.	MAX.	7.387	✓		
5	6.83 RAD.	MAX.	6.840	✓		
6	6.19 RAD.	MAX.	6.075	✓		
7						
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25						

Disposition: 1
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APPR REJECTED _____
 Supervisor _____ Date _____ Signed _____ Engineer _____ Date _____

DOCUMENTED LAYOUT REPORT

Vendor/Dept. No. 930
 PO/PJO 54808 R. R. No. SL 120
 Qty. Rec'd 1 Inspector Wiley
 Date Rec'd Wiley 25 19 88

Part No. 50527 0006 Dwg. Issue 0
 Name DC Current Sensor

ITEM NO.	PRINT DIMEN.	TOLERANCE	ACTUAL DIMEN	ACC	REJ	REMARKS
1	1/16 Dia		.057	✓		
2	3/4 Dia		.750	✓		
3	17 Dia		.169	✓		4 Places
4	1 5/8 Dim		1.625	✓		
5	2 7/8 Dia		2.880	✓		
6	1 3/16 Dia		1.190	✓		
7	1 5/8 Dia		1.622	✓		
8	2 Dia		2.00	✓		
9	2 Dia		2.00	✓		
10	2 9/16 Dia		2.570	✓		
11						
12						
13						
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Disposition 1
2
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APPR REJECTED _____
 Supervisor _____ Date _____ Signed _____ Engineer _____ Date _____ 19 _____

DOCUMENTED LAYOUT REPORT

Dept. No. 930 Part No. 51527 0000 Dwg Issue 0
 PO/PJO 54808 R. R. No. SL 103 Name G. C. U.
 Qty Recd 1 Inspector Max
 Date Rec'd May 25 19 88

ITEM NO	PRINT DIMEN	TOLERANCE	ACTUAL DIMEN	ACC	REJ	REMARKS
1	9.63 Dim	Max	9.635		X	
2	8.50 Dim	Max	8.510		X	
3	9.80 Dim	Max	9.715	✓		
4	4.76 Dim	Max	4.750	✓		
5	57-55	Dim	.575		X	
6	38-37	Dim	.375	✓		
7	25-24	Dim	.260	✓		
8	213-203	Dim	.300		X	4 Places Plant in Holes
9	098-086	Dim	.090	✓		
10	3.75 Dim	Max	3.730	✓		
11	2.94-284	Dim	2.880	✓		
	2.72-262	Dim	2.665	✓		
13	5.72 Dim	Max	5.630	✓		
14	5.60 Dim	Max	5.575	✓		
15	3.55-3.45	Dim	3.490	✓		
16	1.67-1.57	Dim	1.605	✓		
17	Note #3	Max	5.75 #		X	
18						
19						
20						
21						
22						
23						
24						
25						

Disposition: 1 _____
 2 _____
 3 _____
 4 _____
 5 _____
 6 _____

APPR REJECTED _____
 Supervisor _____ Date _____ Signed: _____ Engineer _____ Date _____ 19 _____

Lucas Aerospace

Lucas Aerospace Power Equipment Corporation

DOCUMENTED LAYOUT REPORT

Dept. No. 940

Part No. 51527-000

Dwg Issue 5

FWO 54808

FWO 2497

Name GENERATOR CONTROL UNIT

Qty. Rec'd 1

Inspector ESD

3/11/88

Date Rec'd 6-8

19 88

ITEM NO.	PRINT DIMEN.	TOLERANCE	ACTUAL DIMEN.	ACC	REJ	REMARKS
1	9.63 DIM.	MAX.	9.617/9.648	✓		
2	9.120 DIM.	±.01	9.117/9.127	✓		
3	24.25 DIM.	-	24.1/24.6	✓		
4	4.76 DIM.	MAX.	4.753/4.750	✓		
5	4.00 DIM.	±.01	3.997/4.001	✓		
6	37.38 DIM.	-	37.0/37.8	✓		
7	55.57 DIM.	-	55.5/56.8	✓		
8	9.80 DIM.	MAX.	9.746/9.750	✓		
9	8.50 DIM.	MAX.	8.483/8.497	✓		
10	20.3/213 DIM.	-	20.3/20.7	✓		(4) MOUNTING Holes
11	.086/.098 DIM.	-	.087/.088	✓		
	5.72 DIM.	MAX.	5.620/5.630	✓		
13	5.40 DIM.	MAX.	5.410/5.420	✓		
14	3.45/3.55 DIM.	-	3.403/3.410	✓		
15	1.57/1.67 DIM.	-	1.518/1.520	✓		
16	3.75 DIM.	MAX.	3.626/3.692	✓		
17	2.62/2.72 DIM.	-	2.651/2.653	✓		
18	2.84/2.94 DIM.	-	2.867/2.870	✓		
19	BY NOTE (3.565)	-	5.65	✓		
20						
21						
22						
23						
24						
25						

Disposition

-
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-
-
-
-

APPR REJECTED

Supervisor _____ Date _____ Signed _____ Engineer _____ Date _____ 19 _____

5.2

Overload

Purpose: The purpose of this test was to demonstrate the system's ability to deliver 125% of rated load (208 amperes) for two minutes and maintain voltage regulation within 270 ± 10 volts.

Procedure: The system was connected as shown in Figure 5-1. The generator was operated at rated load (167 amperes) 16,000 rpm until stabilized temperatures were reached. A load of 41 amperes was added and operation maintained for two minutes.

Results: Test results are recorded on data sheet 21284 and chart 21284-A. Oil inlet temperature was 124.4 degrees Fahrenheit. Stator winding temperatures rose from a 333 degrees to a maximum of 454.9 degrees. The voltage was maintained at 263 volts during the overload.

Discussion of Results: The system met the requirements by a comfortable margin. The temperatures and output voltages were well within the limits ordinarily set for winding temperature and the specified voltage regulation.

一、

EXPERIMENTAL LABORATORY, TEST RECORD

COG. ENGR. HARNAI/De IK
 ROTOR NO. STATOR NO.

ALL LABORATORIES: TEST RECORD
SERIAL NO. GCU 103 / CURRENT 326
GEN 101 / SENSORS 123

MODEL NO. SYSTEM 2

w.o. 54805

DATE OF TEST	TEST LETTER: NO.	TESTED BY	STATION NO.
6/9/88	PP387	R. J. SAMICK	

RUSH GRADE

BAR. PRESSURE

M P. AIR GAP

I.P. AIR GAP

FILE: OVERLOAD

OVERLOAD

[illegible]

FORM 1349 8/5 (12/62) PRECEDING PAGE NO. 1

FOLLOWING
PAGE NO.

A.F. SIG.

NO: 21284

OUTPUT VOLTS

EXCITOR CURRENT

OUTPUT AMPS

REF. DATA SHEET 21284

OUTPUT VOLTS $\frac{1}{4}$ Volts Per Div.
LOAD AMPS 50.0 Amps Per Div.
EXCITER CURRENT 0.1 Amps Per Div.

NO: 21284-A

10:42:51 00 JUN 88

RANGES: 67.32V 50.00mV 50.00mV

OFFSETS: 0.0V 0.0V 0.0V

TOTAL TIME: 2.30M

POST-TRIG: 0.0S

TRIGGER: MAN

16000RPM OVERLOAD (125%) 208AMPS

APPLY

5.3

Voltage Regulation and Transient Response

Purposes: The purposes of these tests were to demonstrate the system's ability to meet the voltage regulation and transient response requirements specified.

Procedure: The generator was operated at 9,000, 16,000 and 18,000 rpm. At each of these speeds, loads of 25, 50, 75 and 100 percent were applied and removed.

Results: Test results are recorded on data sheet 22747 and charts 1 through 8 for 9,000 rpm; data sheet 22744 and charts 1 through 8 for 16,000 rpm; data sheet 22748 and charts 1 through 8 for 18,000 rpm. A summary of the transient data is shown in Table 5-2.

Discussion of Results: Throughout the speed and load ranges, the voltage at the point of regulation (POR) changed by a total of 8 volts. Specification allows ± 5.0 volts (total of 10V) only. Since the regulator characteristic is such that the POR voltage droops when load is applied the no-load setting could be moved to 274 volts and with the 8 volts maximum drop the POR voltage would be 266 volts and meeting 270 ± 5 VDC regulation limits.

The load transients (application and removal) voltages and recovery times are summarized in Table 5-2. Recovery times are met under various speed and load conditions, except at low speed (9,000 RPM) under 75 and 100 percent loads. The total closed loop gain of the system required compensation (reduction) at higher speeds to achieve stability. Therefore, this compensation affects the transient response at low speeds where the system gain is much lower. Preliminary studies indicate, that a speed feedback could help, bringing the low speed transient response closer to specification limits.

5.4

Voltage Ripple

Purpose: The purpose of this test was to demonstrate that the ripple voltage was equal or less than that required by the specification.

Procedure: This test was done simultaneously with the voltage regulation test, paragraph 5.3 above.

Results: Test results are recorded on data sheets 22744, 22747, and 22748. appended to the voltage regulation test.

Discussion of Results: The test results showed that at all conditions of load and speed, the voltage ripple was less than the 12 volts required by the specification.

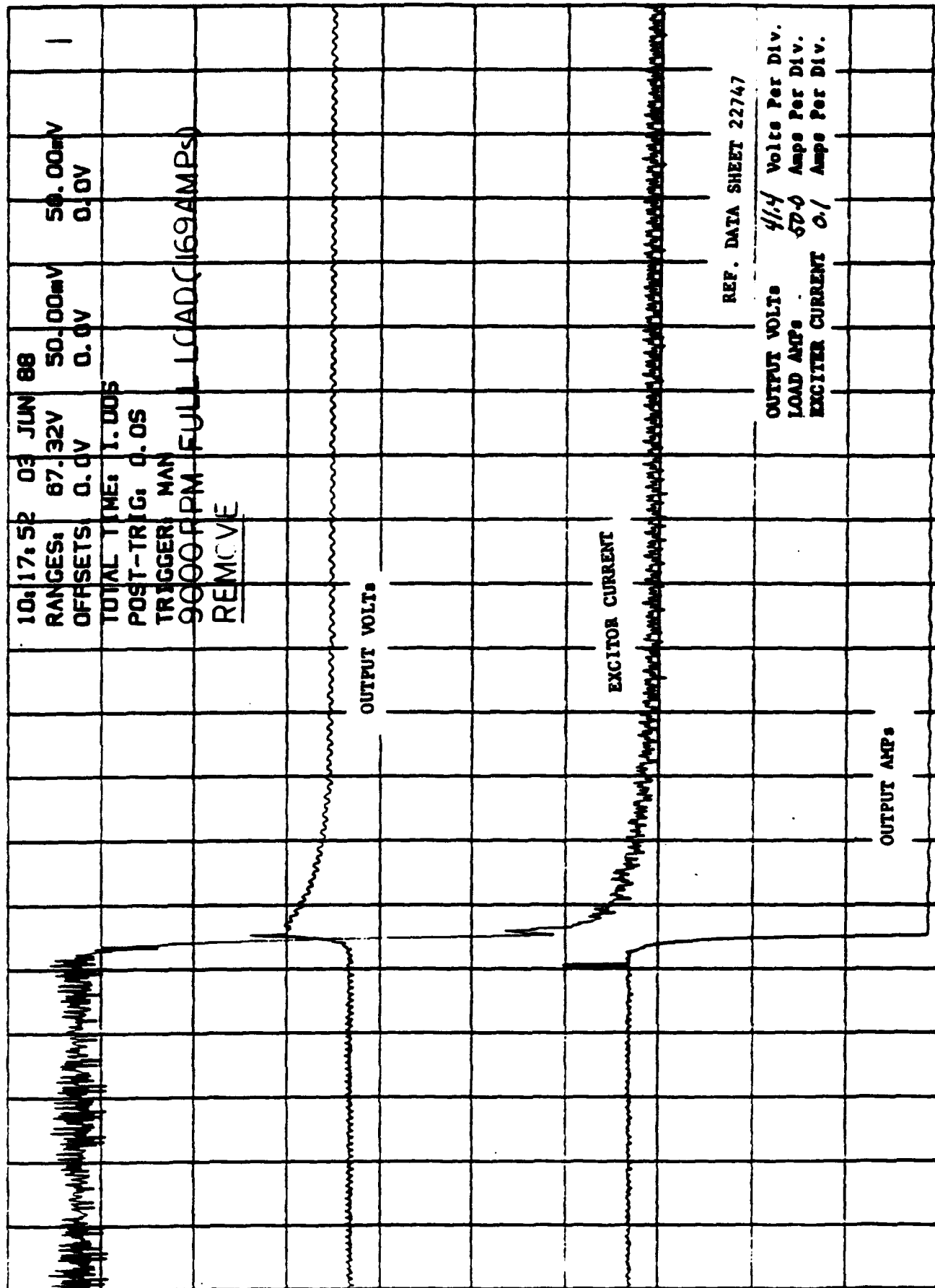
TABLE 5-2

Summary of Transient Performance Test Results

<u>RPM</u>	<u>% Load</u>	<u>Application</u>		<u>Removal</u>	
		<u>Minimum Voltage</u>	<u>Recovery (Seconds)</u>	<u>Maximum Voltage</u>	<u>Recovery (Seconds)</u>
9,000	100	223	0.077	305	0.070
9,000	75	236	0.040	289	0.030
9,000	50	219	0.022	279	0.022
9,000	25	249	0.010	*	*
16,000	100	214	0.024	307	0.030
16,000	75	208	0.006	290	0.028
16,000	50	255	0.014	282	0.024
16,000	25	260	0.011	*	*
18,000	100	217	0.032	305	0.040
18,000	75	248	0.012	291	0.024
18,000	50	231	0.016	281	0.020
18,000	25	257	0.020	*	*

* Does not exceed voltage regulation limits

NOTE: Specification requires for load application and removal, minimum voltage of 175 volts, maximum voltage of 350 volts, and recovery time of 0.033 second.



EXCITOR CURRENT

OUTPUT VOLTS

OUTPUT AMP

REF. DATA SHEET 22747

OUTPUT VOLTS 41.4 Volts Per Div.
 LOAD AMPs 50.0 Amps Per Div.
 EXCITER CURRENT 2.1 Amps Per Div.

10:22:51 03 JUN 88
 RANGES: 67.32V 50.00mV 50.00mV
 OFFSETS: 0.0V 0.0V 0.0V

TOTAL TIME: 1.00S

POST-TRIG: 0.0S

TRIGGER: MAN

9000RPM FULL LOAD(1634APs)

APPLY

10:28:20

03 JUN 88

RANGES:

67.32V

50.00mV

50.00mV

3

OFFSETS:

0.0V

0.0V

0.0V

TOTAL TIME: 1.00S

POST-TRIG: 0.0S

TRIGGER: MAN

9000RPM 3/4 LOAD (125AMPS)

REMOVE

OUTPUT VOLTS

EXCITOR CURRENT

REF. DATA SHEET 22747

OUTPUT VOLTS 4/4 Volts Per Div.

LOAD AMPS 57.6 Amps Per Div.

EXCITER CURRENT 0.1 Amps Per Div.

OUTPUT AMPS

OUTPUT VOLTS

EXCITOR CURRENT

OUTPUT AMPs

10.31.49 03 JUN 88

RANGES: 67.32V 50.00mV 50.00mV

OFFSETS: 0.0V 0.0V 0.0V

TOTAL TIME: 1.00S

POST-TRIG: 0.0S

TRIGGER: MAN

9000RPM 3/4 LOAD (125 AMPs)

APPLY

REF. DATA SHEET 22747

OUTPUT VOLTS 4/4 Volts Per Div.

LOAD AMPs 67.0 Amps Per Div.

EXCITER CURRENT 0/ Amps Per Div.

5

10: 37: 00 03 JUN 88

RANGES: 67.32V 50.00mV 50.00mV

OFFSETS: 0.0V 0.0V 0.0V

TOTAL TIME: 1.00S

POST-TRIG: 0.0S

TRIGGER: MAN

9000RPM 1/2 LOAD (85AMPS)

REMOVE

OUTPUT VOLTS

EXCITOR CURRENT

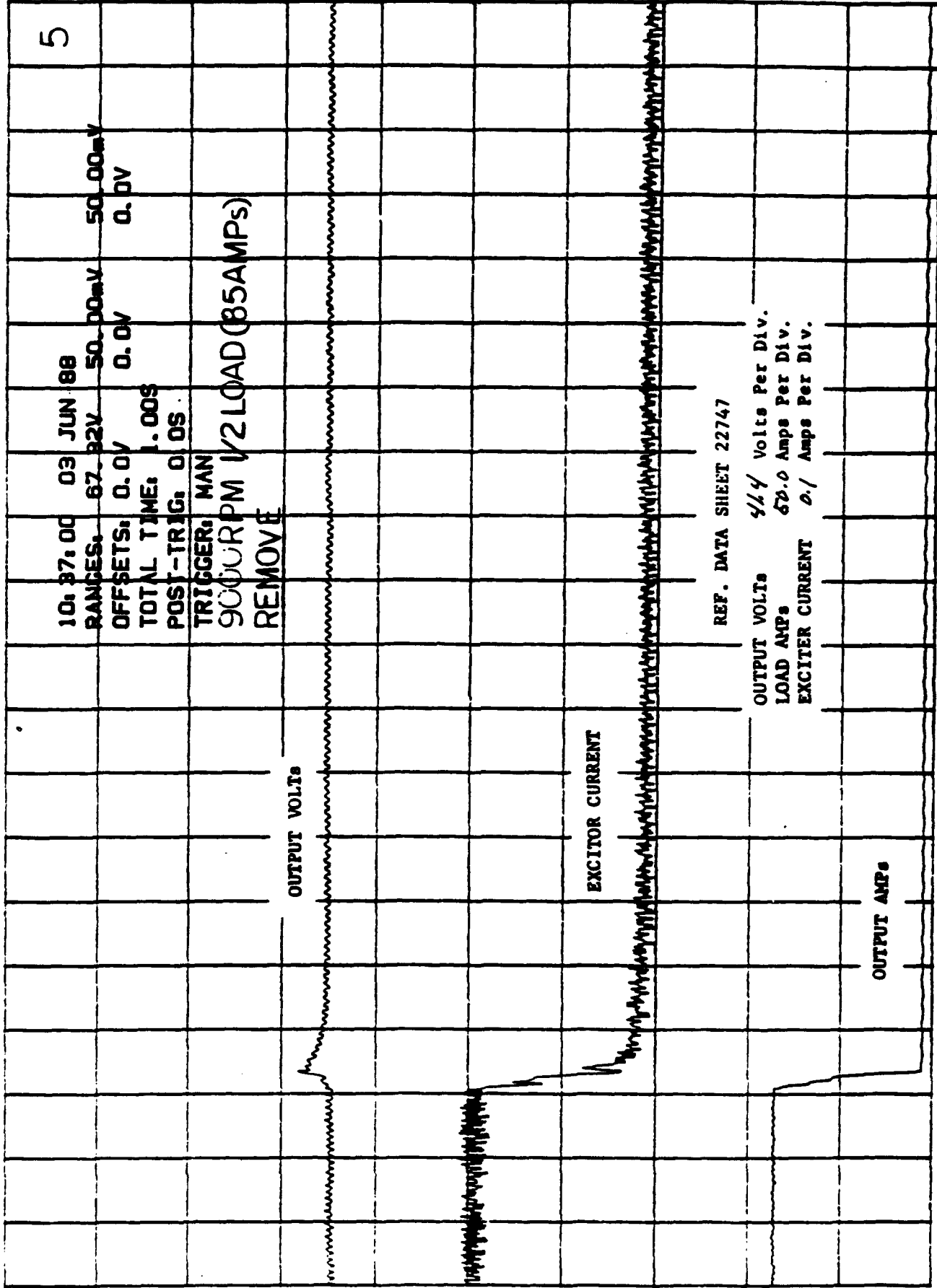
OUTPUT AMPS

REF. DATA SHEET 22747

OUTPUT VOLTS 4/4 Volts Per Div.

LOAD AMPS 50.0 Amps Per Div.

EXCITER CURRENT 0.1 Amps Per Div.



OUTPUT VOLTS

10.42.20 03 JUN 88

RANGES: 67.32V 50.00mV 50.00mV
 OFFSETS: 0.0V 0.0V 0.0V

TOTAL TIME: 1.00S

POST-TRIG: 0.0S

TRIGGER: MAN

9000RPM 1/2 LOAD (85AMPS)

APPLY

REF. DATA SHEET 22747

EXCITOR CURRENT

OUTPUT VOLTS 41.4 Volts Per Div.
 LOAD AMPS 50.0 Amps Per Div.
 EXCITER CURRENT 0.1 Amps Per Div.

OUTPUT AMP

10: 47: 57

RANGES:

OFFSETS:

TOTAL TIME:

POST-TRIG:

TRIGGER:

MAN

9000RPM 1/4 LOAD (13AMPS)

REMOVE

03 JUN 88

87.32V

0.0V

1.00S

0.0S

MAN

50.00mV

0.0V

50.00mV

0.0V

50.00mV

0.0V

OUTPUT VOLTS

EXCITOR CURRENT

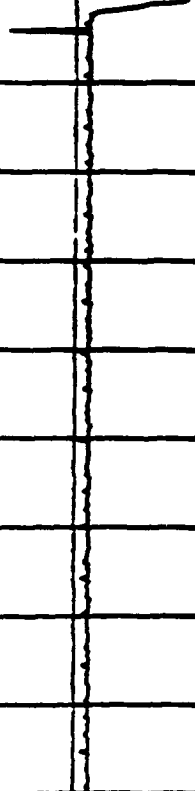
OUTPUT AMPS

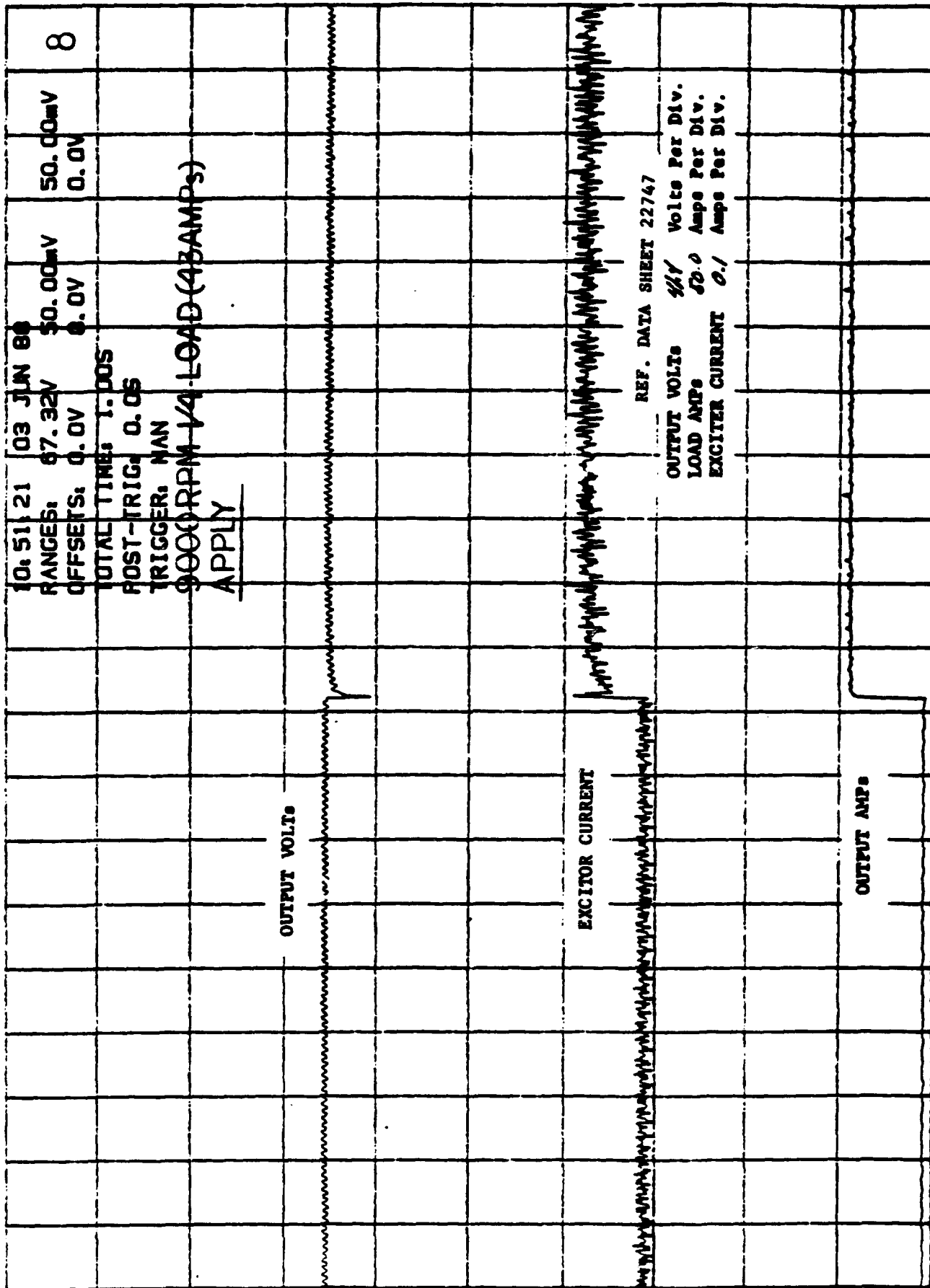
REF. DATA SHEET 22747

OUTPUT VOLTS 41.4 Volts Per Div.

LOAD AMPS 50.0 Amps Per Div.

EXCITER CURRENT 0.1 Amps Per Div.





REF. DATA SHEET 22747

OUTPUT VOLTS 1/1 Volts Per Div.
 LOAD AMPS 50.0 Amps Per Div.
 EXCITER CURRENT 0.1 Amps Per Div.

COG. ENGR. *Harriet Dean*
 ROTOR NO. STATOR NO.

EXPERIMENTAL LABORATORY TEST RECORD
862 103 / CURRENT 326
44 2 SERIAL NO. 664 101 / REMARKS 123

E.W.O. 54805-

MODEL NO. 5Y

DATE OF TEST 5/31/88

TEST LETTER: NO. QP 387

TESTED BY R. J. SANIUK

BRUSH GRADE

BAR. PRESSURE

M P. AIR GAP

I.P. AIR GAP

TITLE:

VOLTAGE REGULATION

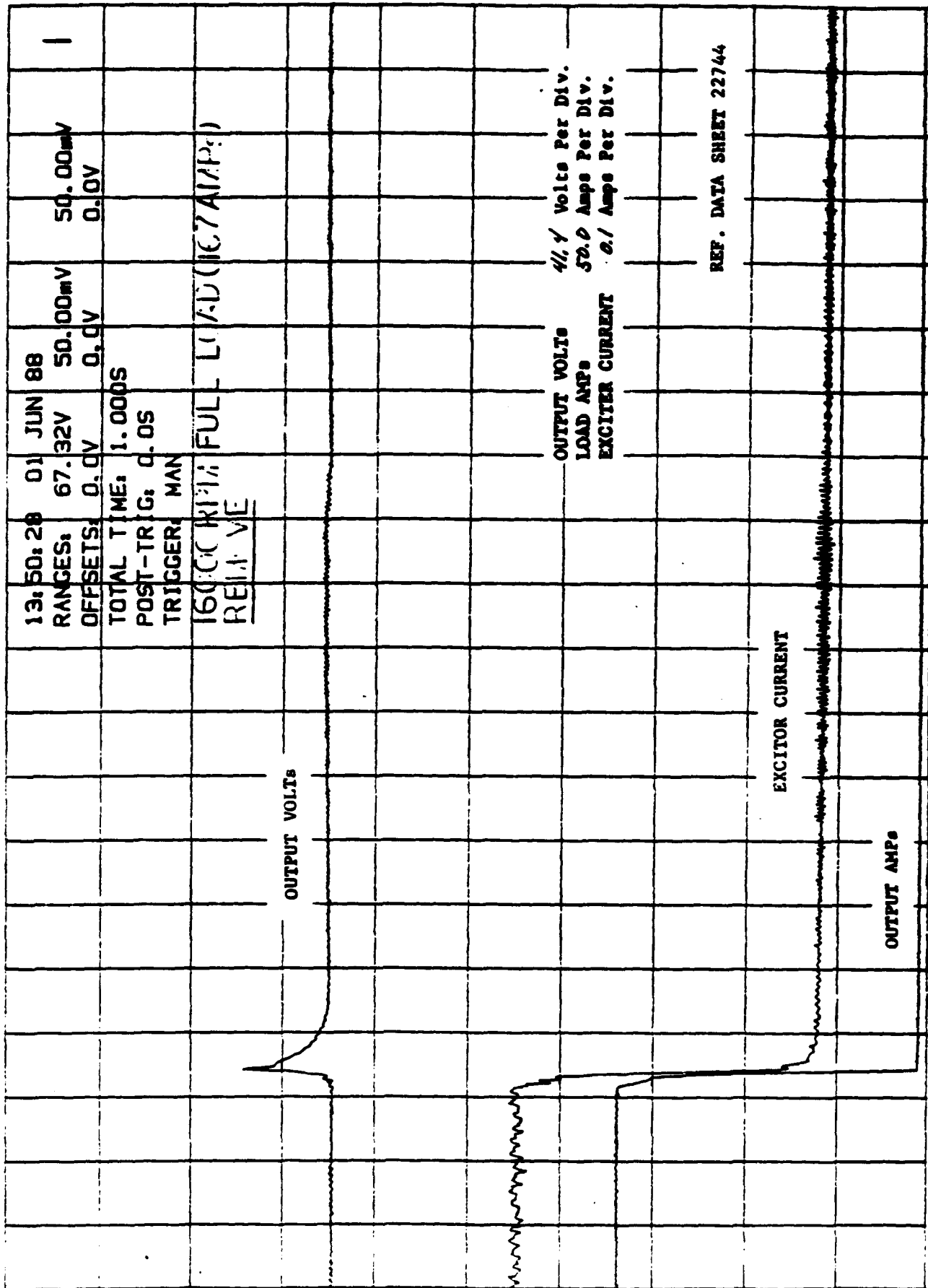
16

PAGE / OF 3

[illegible]

PRECEDING	PAGE NO
908M 1349 R/3 (117/62)	

FOLLOWING
PAGE NO.



13:54:36 01 JUN 88

RANGES: 67.32V 50.00mV 50.00mV
OFFSETS: 0.0V 0.0V 0.0V

TOTAL TIME: 1.000S
POST-TRIG: 0.0S
TRIGGER: MAN

16000 RPM FULL LOAD (167 AMPS)
APPLY

OUTPUT VOLTS

EXCITOR CURRENT

OUTPUT AMPS

REF. DATA SHEET 22744
OUTPUT VOLTS 41.4 Volts Per Div.
LOAD AMPS 59.0 Amps Per Div.
EXCITER CURRENT 0.1 Amps Per Div.

13:58:29 01 JUN 88

RANGES: 67.92V 50.00mV 50.00mV

OFFSETS: 0.0V 0.0V 0.0V

TOTAL TIME: 1.000S

POST-TRIG: 0.0S

TRIGGER: MAN

16000 RPM

REMOVE

3/4 LOAD (125AMPS)

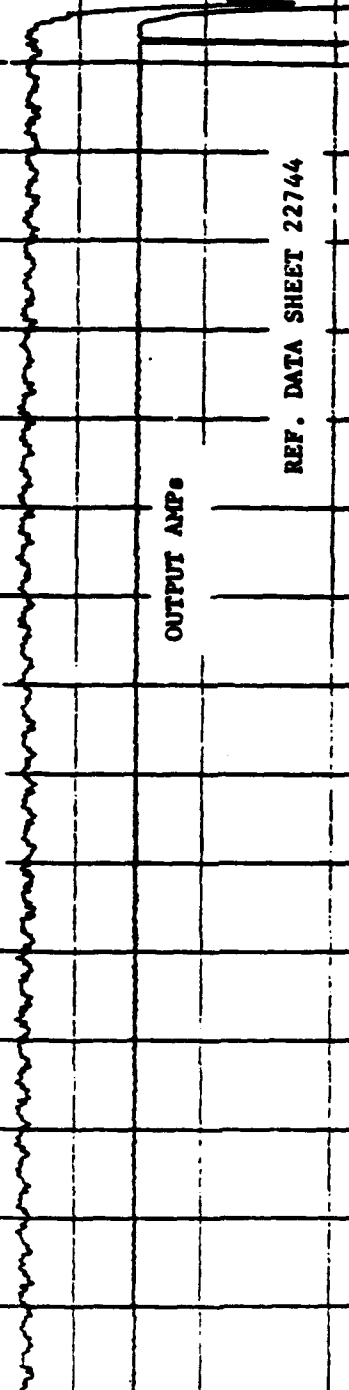
OUTPUT VOLTS

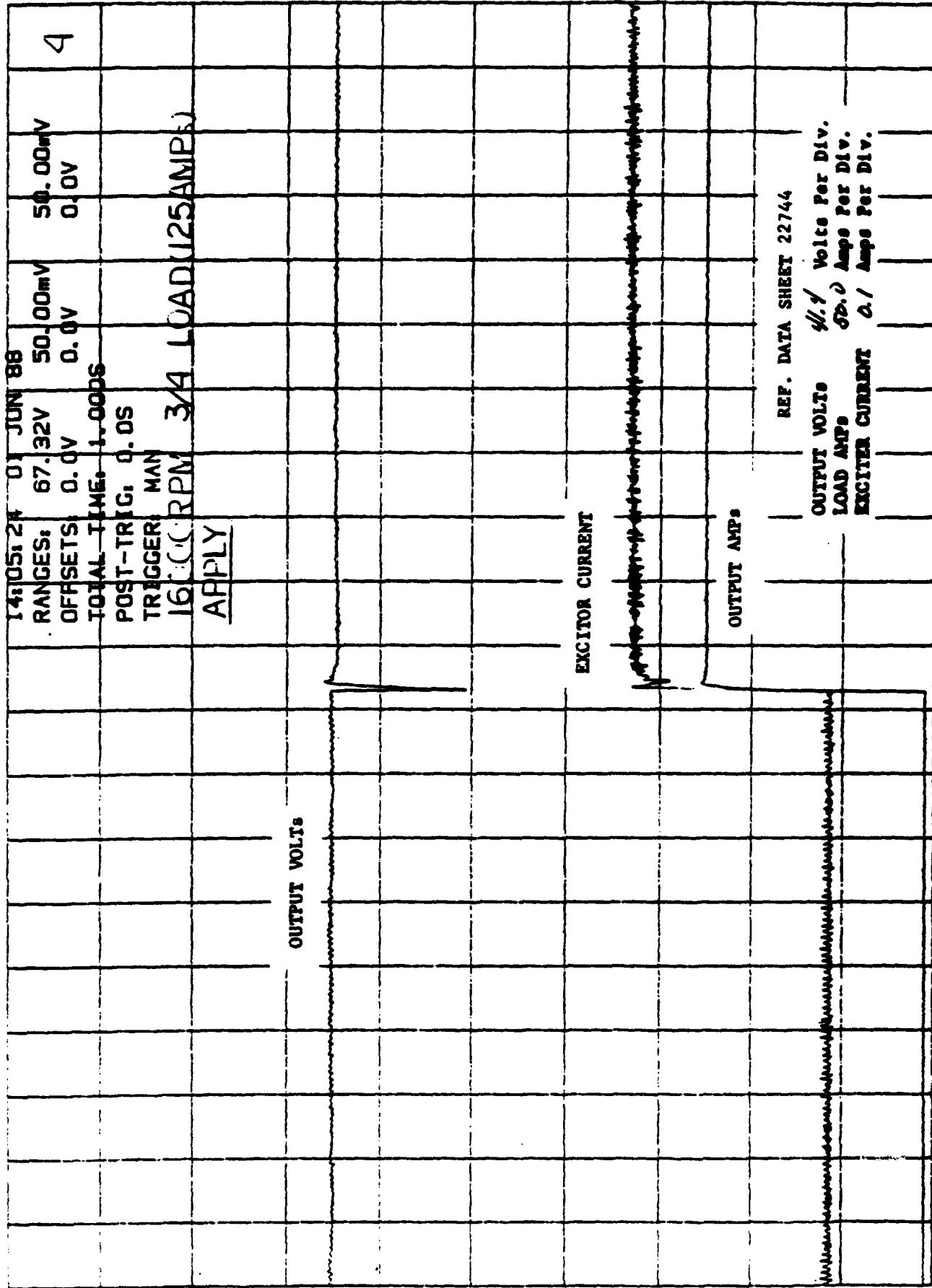
OUTPUT VOLTS 4/1 Volts Per Div.
LOAD AMPS 50.0 Amps Per Div.
EXCITER CURRENT 0.1 Amps Per Div.

EXCITER CURRENT

OUTPUT AMPS

REF. DATA SHEET 22744





14.14.45 01 JUN 88

RANGES 67.32V 50.00mV 50.00mV

OFFSETS 8.8V 8.8V 8.8V

TOTAL TIME: 1.000S

POST-TRIG: 0.0S

TRIGGER: MAN

16000RPM 1/2 LOAD (84AMPS)

REMOVE

OUTPUT VOLTS



EXCITOR CURRENT



OUTPUT AMPS

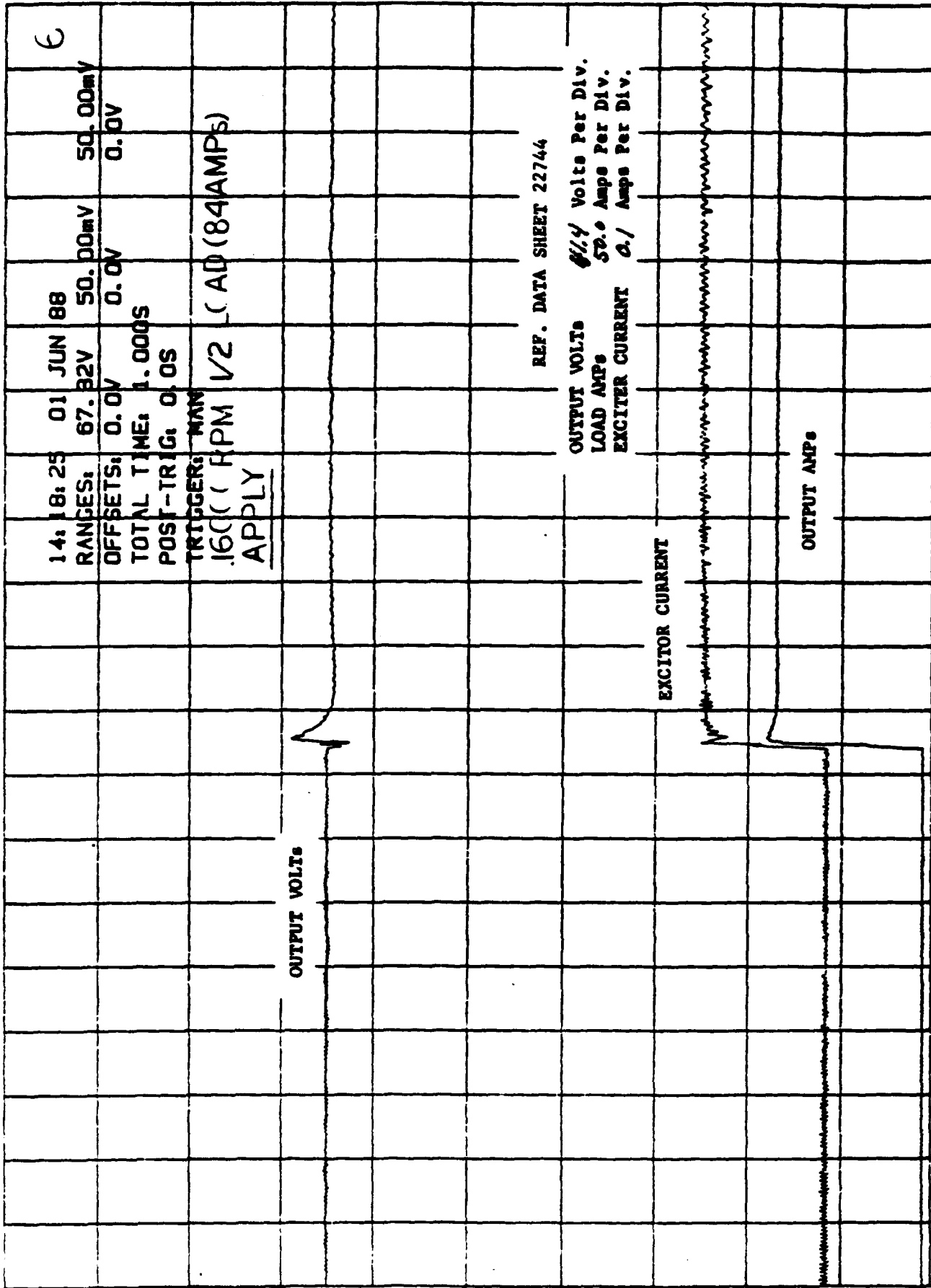


REF. DATA SHEET 22744

OUTPUT VOLTS 41.4 Volts Per Div.

LOAD AMPS 52.0 Amps Per Div.

EXCITER CURRENT 0.1 Amps Per Div.



14:29:02 01 JUN 88

RANGES: 87.32V 50.00mV 50.00mV

OFFSETS: 8.8V 0.8V 0.8V

TOTAL TIME: 1.000S

POST-TRIG: 0.0S

TRIGGER: MAN

1600.0RPM 1/4 LOAD (43 AMPS)

APPLY

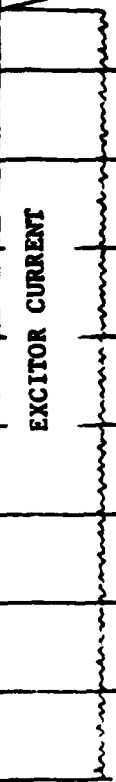
OUTPUT VOLTS



REF. DATA SHEET 22744

OUTPUT VOLTS 41.4 Volts Per Div.
LOAD AMPS 52.0 Amps Per Div.
EXCITER CURRENT 0.1 Amps Per Div.

EXCITOR CURRENT



OUTPUT AMPS



14:24:25 01 JUN 88

RANGES: 67.32V 50.00mV 50.00mV

OFFSETS: 0.0V 0.0V 0.0V

TOTAL TIME 1.000S

POST-TRIG: 0.0S

TRIGGER: MAN

16000RPM 1/4 LOAD (13AMPs)

REMOVE

OUTPUT VOLTS

EXCITOR CURRENT

OUTPUT AMPs

REF. DATA SHEET 22744

OUTPUT VOLTS 4/4 Volts Per Div.

LOAD AMPs 50.0 Amps Per Div.

EXCITER CURRENT 0.1 Amps Per Div.

E.W.O. 54805

DATE OF TEST 6/6/88

TEST LETTER: NO. PP387

TESTED BY R. J. SAVINIK

BRUSH GRADE

BAR. PRESSURE

M.P. AIR GAP

I.P. AIR GAP

VOLTAGE REGULATION STABLE 16K - TEST 1800 RPM																PAGE 3 OF 3	
TIME	RPM	GEN	OUT VOLT	OUT AMP	Excitor	IN	OUT	TEMP OF	CASE	GEAR OIL IN	OIL PRESSURE IN	GEAR OIL OUT	GEAR OIL MIN	SAFETY	RUN	CHART	
				AMP LOAD											+	-	
16000	0917	85.5	267.6	169	0.443	113.5	186.0	356.0	338.3	172.5	173.9	6.0	11.0	560	3.24	8.0	4.0
16050	0924	86.9	267.3	169	0.445	120.9	165.2	387.8	382.7	162.0	143.3	7.0	11.0	590	3.43	2.5	4.0
16050	0930	87.3	267.3	169	0.445	122.1	167.4	390.4	386.7	165.6	144.4	7.0	11.0	552	3.43	2.5	4.0
16050	0935	87.8	267.3	169	0.445	122.1	167.5	389.5	386.9	163.2	145.0	7.0	11.0	585	3.44	2.5	4.0
16050	0940	87.9	267.4	162	0.445	122.6	167.9	388.4	386.1	166.0	146.1	7.0	11.0	586	3.45	2.5	4.0
18000	0942	87.3	268.1	170	0.441	124.4	170.2	375.9	382.7	166.5	146.5	7.0	11.0	620	3.59	4.0	4.0
17000	0945	86.5	267.3	169	0.443	124.9	170.3	350.0	350.2	168.8	148.5	7.0	11.0	615	3.56	2.0	4.0
18150	0948	86.5	268.7	0	0.105	125.0	170.3	325.9	348.9	163.9	148.5	7.0	11.0	585	3.44	2.0	2.0
18000	0952	87.3	267.6	125	0.132	117.0	158.4	271.2	271.7	153.3	139.2	7.0	11.0	585	3.44	4.0	4.0
18350	0954	86.7	268.3	125	0.135	115.9	156.3	258.3	260.1	151.5	138.9	7.0	11.0	589	3.41	4.0	4.0
18150	0957	87.5	268.9	0	0.111	115.4	157.8	250.3	260.7	148.6	137.3	7.0	10.5	572	3.31	2.0	2.0
18000	1001	87.0	266.9	84	0.235	109.7	147.0	214.0	213.8	142.0	131.7	6.5	10.0	565	3.27	4.0	4.0
17550	1003	86.9	267.6	84	0.236	109.9	146.7	210.4	210.5	141.8	131.9	6.5	10.0	509	3.24	3.0	4.0
18000	1007	87.2	268.6	0	0.101	109.3	145.7	192.7	188.6	138.9	131.5	6.0	10.0	560	3.24	2.0	2.2
18000	1010	85.4	266.6	43	0.156	107.5	143.8	182.2	182.6	137.3	129.3	6.0	10.0	561	3.25	3.0	2.5
17800	1012	85.4	266.4	43	0.157	107.1	143.1	178.6	180.5	136.4	129.0	6.0	10.0	555	3.21	2.0	2.5
18000	1016	85.2	269.1	0	0.111	106.1	140.6	175.9	172.3	135.0	127.8	6.0	10.0	550	3.18	2.0	2.1
1605	1019	86.2	268.7	169	0.444	105.2	140.8	208.3	232.0	132.6	124.9	6.0	10.0	545	3.16	2.0	4.0

PRECEDING

FOLLOWING

COR. FLOW RATE 174 X 174

09:48:37 06 JUN 88

RANGES: 67.32V 50.00mV 50.00mV

OFFSETS: 0.0V 0.0V 0.0V

TOTAL TIME: 1.00S

POST-TRIG: 0.0S

TRIGGER: MAN

1800 RPM FULL LOAD (16.7 AMPS)

APPLY

OUTPUT VOLTS

EXCITOR CURRENT

OUTPUT AMPS

REF. DATA SHEET 22748

OUTPUT VOLTS 11.4 Volts Per Div.

LOAD AMPS 50.3 Amps Per Div.

EXCITER CURRENT 0.1 Amps Per Div.

REF. DATA SHEET 22748

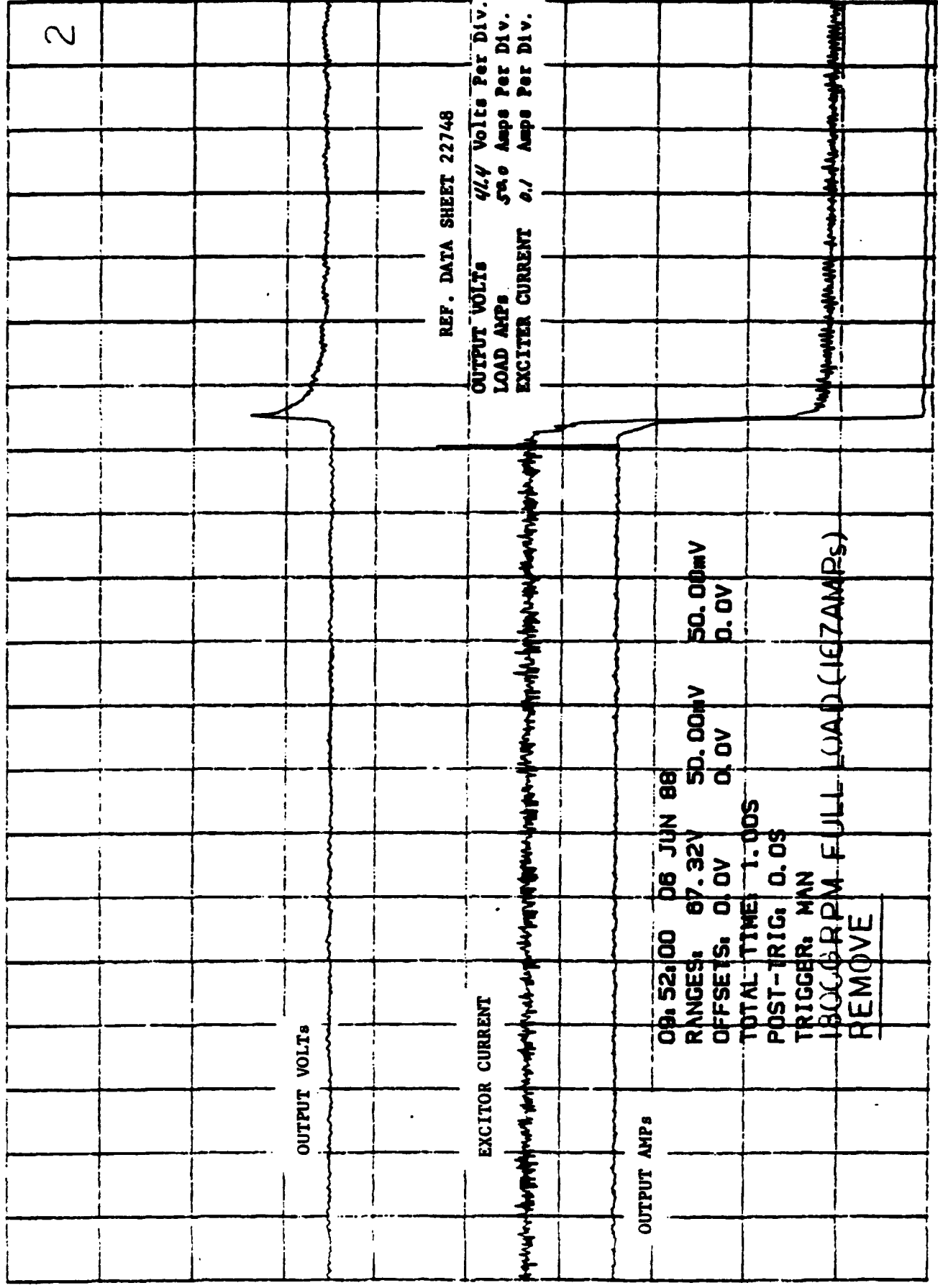
OUTPUT VOLTS 44.4 Volts Per Div.
 LOAD AMPS 50.0 Amps Per Div.
 EXCITER CURRENT 0.1 Amps Per Div.

OUTPUT VOLTS

EXCITER CURRENT

OUTPUT AMPS

09:52:00 06 JUN 88
 RANGES: 87.32V 50.00mV 50.00mV
 OFFSETS: 0.0V 0.0V 0.0V
 TOTAL TIME: 1.00S
 POST-TRIG: 0.0S
 TRIGGER: MAN
 1800 RPM FULL LOAD (167 AMPS)
 REMOVE



OUTPUT VOLTS



REF. DATA SHEET 22748

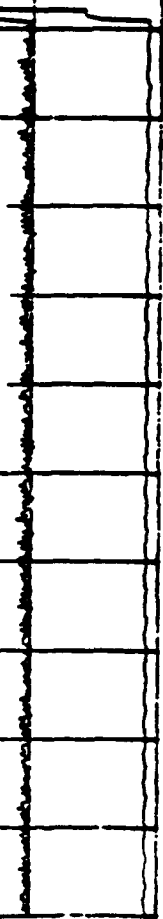
OUTPUT VOLTS 4/1 Volts Per Div.
 LOAD AMPS 50.0 Amps Per Div.
 EXCITER CURRENT 0.1 Amps Per Div.

08:57:43 06 JUN 88
 RANGES: 67.32V 50.00mV 50.00mV
 OFFSETS: 0.0V 0.0V 0.0V
 TOTAL TIME: 1.00S
 POST-TRIG: 0.0S
 TRIGGER: MAN
 1800RPM 3/4 LOAD(125AMP:)
 APPLY



OUTPUT AMPS

EXCITOR CURRENT



1

OUTPUT VOLTS

REF. DATA SHEET 22748

OUTPUT VOLTS 44V Volts Per Div.
LOAD AMPS 50.0 Amps Per Div.
EXCITER CURRENT 0.1 Amps Per Div.

EXCITOR CURRENT

OUTPUT AMPS

10:01:11 06 JUN 88
RANGES: 87.32V 50.00V 50.00mV
OFFSETS: 0.0V 0.0V 0.0V
TOTAL TIME: 1.00S
POST-TRIG: 0.0S
TRIGGER: MAN

1800RPM 34 LOAD (125 AMP)
REVERSE

OUTPUT VOLTS

10:07:00 06 JUN 88

RANGES: 67.32V 50.00mV 50.00mV

OFFSETS: 0.0V 0.0V 0.0V

TOTAL TIME: 1.00S

POST-TRIG: 0.0S

TRIGGER: MAN

1800 RPM 1/2 LOAD (84AMP)

APPLY

REF. DATA SHEET 22748

OUTPUT VOLTS

4/4 Volts Per Div.

LOAD AMPS

50.0 Amps Per Div.

EXCITER CURRENT

0.1 Amps Per Div.

EXCITOR CURRENT

OUTPUT AMPS

6

OUTPUT VOLTS

10:10:40 06 JUN 88
RANGES: 87.32V 50.00mV 50.00mV
OFFSETS: 0.0V 0.0V 0.0V
TOTAL TIME: 1.00S
POST-TRIG: 0.0S
TRIGGER: MAN
18000RPM 1/2 LOAD (81AMP)
REMOVE

REF. DATA SHEET 22748

OUTPUT VOLTS 4/4 Volts Per Div.
LOAD AMPS 50.0 Amps Per Div.
EXCITER CURRENT 2.1 Amps Per Div.

EXCITOR CURRENT

OUTPUT AMPS

OUTPUT VOLTS

10.16.36 08 JUN 88
RANGES: 67.32V 50.00mV 50.00mV
OFFSETS: 0.0V 0.0V 0.0V
TOTAL TIME: 1.00S
POST-TRIG: 0.0S
TRIGGER: MAN

REF. DATA SHEET 22748

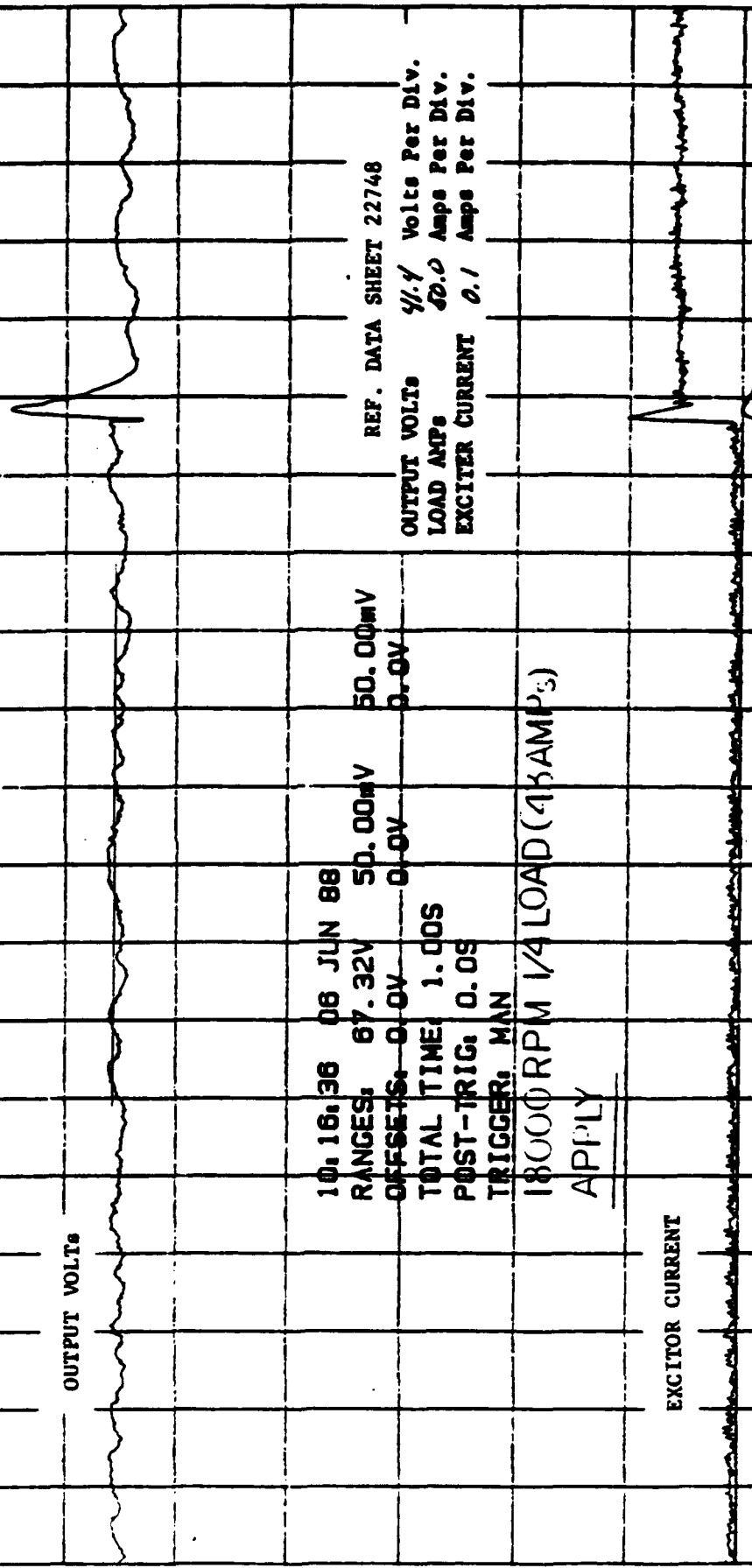
OUTPUT VOLTS 41.4 Volts Per Div.
LOAD AMPS 50.0 Amps Per Div.
EXCITER CURRENT 0.1 Amps Per Div.

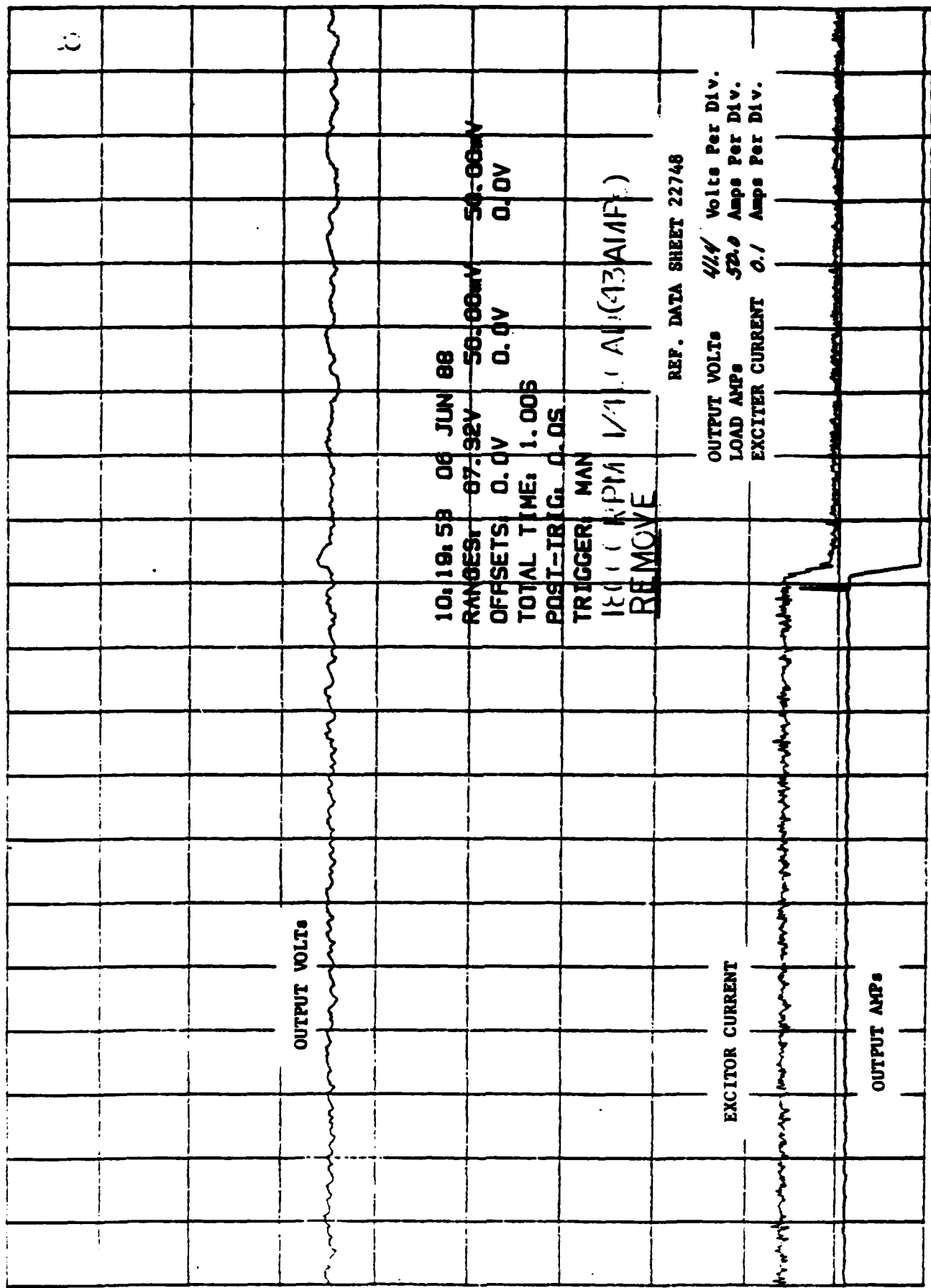
18000 RPM 1/4 LOAD (43 AMPs)

APPLY

EXCITER CURRENT

OUTPUT AMPS





10.19.58 06 JUN 88
RANGES: 87.92V 50.00mV 50.00mV
OFFSETS: 0.0V 0.0V 0.0V
TOTAL TIME: 1.00S
POST-TRIG: 0.0S
TRIGGER: MAN
1200 RPM 1/1 (13A1AF)
REMOVE

REF. DATA SHEET 22748

OUTPUT VOLTS 41.4 Volts Per Div.
LOAD AMPS 52.0 Amps Per Div.
EXCITER CURRENT 0.1 Amps Per Div.

5.5

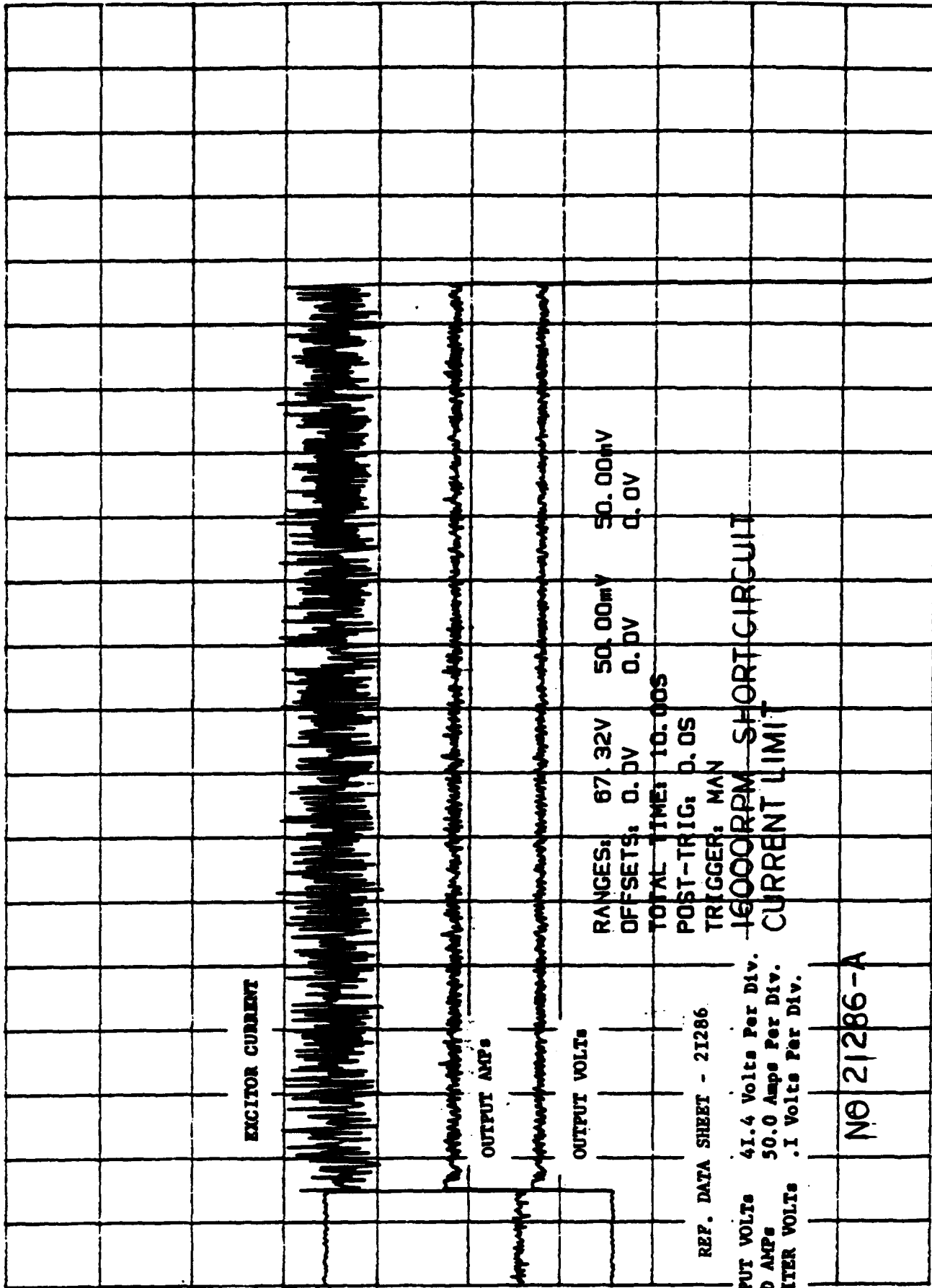
Short Circuit Capacity

Purpose: The purpose of this test was to verify the system's ability to deliver 150 percent of rated current (250 amperes) for seven seconds.

Procedure: The generator was operated at rated load (167 amperes) and 16,000 rpm until stabilized. At that time a 200 ampere additional load was applied for seven seconds. It was necessary to disable the undervoltage circuit of the GCU so that the system would operate for the full seven seconds.

Results: Test results are recorded on data sheet 21286 and chart 21286-A

Discussion of Results: The current limit of the GCU limited the generator current to 250 amperes. Winding temperatures changed unperceptibly. The requirement was met.



5.6

Paralleling

Purpose: the purpose of this test was to demonstrate that two systems operated in parallel meet specified voltage and load-sharing requirements.

Procedure: Two systems, connected in parallel, were operated at 16,000 rpm with rated load on each system. Operation was continued until both systems reached temperature stabilization.

Following stabilization, the following tests were run:

<u>Test</u>	<u>System</u>	<u>Speed</u>	<u>Bus Loads</u>
1	I	16,000 rpm	1/3, 2/3, Full
	II	9,000 rpm	
2	I	9,000 rpm	1/3, 2/3, Full
	II	9,000 rpm	
3	I	18,000 rpm	1/3, 2/3, Full
	II	9,000 rpm	

Results: Test 1 results were recorded on: data sheets 19941-A and charts 19941-A 1 through 6 for system I; data sheets 19941-B and charts 19941-B1 through 6 for system II. Test 2 results were recorded on: data sheets 19941-C and charts 19941-C1 through 6 for system I; data sheets 19941-D and charts 19941-D1 through 6 for system II.

Test 3 results were recorded as: data sheets 19941-E and charts 19941-E1 through 6 for system I; data sheets 19941-F and charts 19941-F1 through 6 for system II. A summary of the transient data is shown as Table 5-3.

Discussion of Results: The summary of test data shown in Table 5-3 indicates, that the two parallel generator systems met the specification requirements. Some anomalies shown mostly at the low speed (9,000 rpm) operation, where high modulation was experienced (see traces) can be explained by the generator drive stand "hunting" effect. The modulation frequency varied from 80-150 Hz. which could have been caused by the gear-box or drive-shaft resonant frequencies.

TABLE 5-3

Paralleling: Transient Performance

<u>Test</u>	<u>Bus Load</u>	<u>RPM</u>	<u>Max. Volts</u>	<u>Recovery MS.</u>	<u>Min. Volts</u>	<u>Recovery MS.</u>	<u>RPM</u>	<u>Max. Volts</u>	<u>Recovery MS.</u>	<u>Min. Volts</u>	<u>Recovery MS.</u>
1	1/3	16,000	273	10	258	12	9,000	272	3	258	12
	2/3		283	12	238	6		285	8	236	6
	Full		280	24	215	12		281	18	250	12
2	1/3	9,000		INDETERMINATE			9,000		INDETERMINATE		
	2/3		280	10	245	7		286	26	INDETERMINATE	
	Full		280	20	238	10		280	10	226	33
3	1/3	18,000		WITHIN REGULATION LIMITS*			9,000		WITHIN REGULATION LIMITS*		
	2/3		280	32	246	12		275	10	249	8
	Full		281	20	242	20		281	18	238	20

* Steady State Limits

LUCKS NEED-PRICE
POWER EQUI. CORP.

EXPERIMENTAL LABORATORY TEST RECORD

MODEL NO. SYSTEM I

SERIAL NO. GEN 121 / CURRENT 121
GEN 121 / DYNAMO 121

COG. ENGR. HARMATINSKI

ROTOR NO.

STATOR NO.

E.W.O. 54805

DATE OF TEST 7/14/88

TEST LETTER: NO. QP 387

TESTED BY R.J. SANIUK

BRUSH GRADE

BAR. PRESSURE

M.P. AIR GAP

I.P. AIR GAP

PARALLEL SYSTEMS 9000 & 16000 RPM.														PAGE		OF	
TIME	GEN	OUT VOLT	OUT AMP	EXCIT. AMP	OUT IN	OUT #1	STATOR #2	CASE	GEAR BOX	IN	OUT	OUT CYCLES	PER MIN	RIPPLE +	PER -	NO.	
1345	97.5	266.3	85	0.23	94.5	121.8	186.6	112.7	111.7	81.0	14.5	555	3.36	2.0	3.0		
1400	98.4	266.2	85	0.235	94.8	131.7	214.8	130.8	124.6	81.0	14.0	555	3.36	2.0	2.5		
1405	99.1	266.3	85	0.233	94.0	132.0	215.5	130.8	124.6	81.0	14.0	555	3.36	2.0	2.5		
1410	100.4	266.4	85	0.234	94.0	132.1	216.0	131.7	125.0	81.0	14.0	555	3.36	2.0	2.5		
1415	100.0	266.4	85	0.235	94.0	132.1	216.4	132.2	125.6	81.0	14.0	555	3.36	2.0	2.5		
1418	99.4	265.7	86	0.24	93.5	132.5	218.4	131.7	125.2	81.0	14.0	555	3.36	2.2	2.5		
1421	100.0	267.6	54	0.11	94.0	131.9	141.8	130.7	126.3	81.0	14.0	555	3.36	2.0	2.0	1	
1425	99.5	265.8	87	0.24	92.5	130.5	206.3	129.2	124.0	81.0	14.0	555	3.36	2.2	2.5	2	
1431	100.0	265.5	60	0.17	94.0	131.0	197.3	129.8	124.9	81.0	14.0	555	3.36	2.0	2.5		
1434	99.7	267.5	54	0.15	92.0	129.8	189.6	127.5	124.2	81.0	14.0	555	3.36	2.0	1.5	3	
1439	99.0	265.6	60	0.19	93.5	127.2	180.8	125.6	122.4	81.0	14.0	555	3.36	2.0	2.0	4	
1444	98.8	266.3	30	0.14	94.0	127.2	174.9	124.9	121.8	81.0	14.0	555	3.36	2.2	2.2		
1448	98.4	267.3	54	0.12	94.0	126.6	170.2	123.9	121.7	81.0	14.5	555	3.36	2.0	2.0	5	
1453	97.9	265.9	30	0.14	94.0	125.8	167.4	122.8	120.5	81.0	14.0	555	3.36	2.0	2.2	6	
1458	99.7	266.6	85	0.24	93.0	128.2	199.5	126.6	122.0	81.0	14.3	555	3.36	2.2	2.5		

GS

OUTPUT VOLTS

RANGES: 67.32V 50.00mV 50.00mV
OFFSETS: 0.0V 0.0V 0.0V
TOTAL TIME: 1.00S
POST-TRIG: 0.0S
TRIGGER: EXT

PARALLEL SYSTEMS
REF. DATA SHEET 1994I-A

OUTPUT VOLTS 42.7 Volts Per Div.
LOAD AMPs 52.0 Amps Per Div.
EXCITER CURRENT 0.1 Amps Per Div.

ISYS1: SYS 2
16000 & 9000 RPM
FULL LOAD (86 AMPS)

REMI VE

EXCITOR CURRENT

OUTPUT AMPs

OUTPUT VOLTS

RANGES: 67.32V 50.00mV 50.00mV
 OFFSETS: 0.0V 0.0V 0.0V
 TOTAL TIME: 1.00S
 POST-TRIG: 0.0S
 TRIGGER: EXT

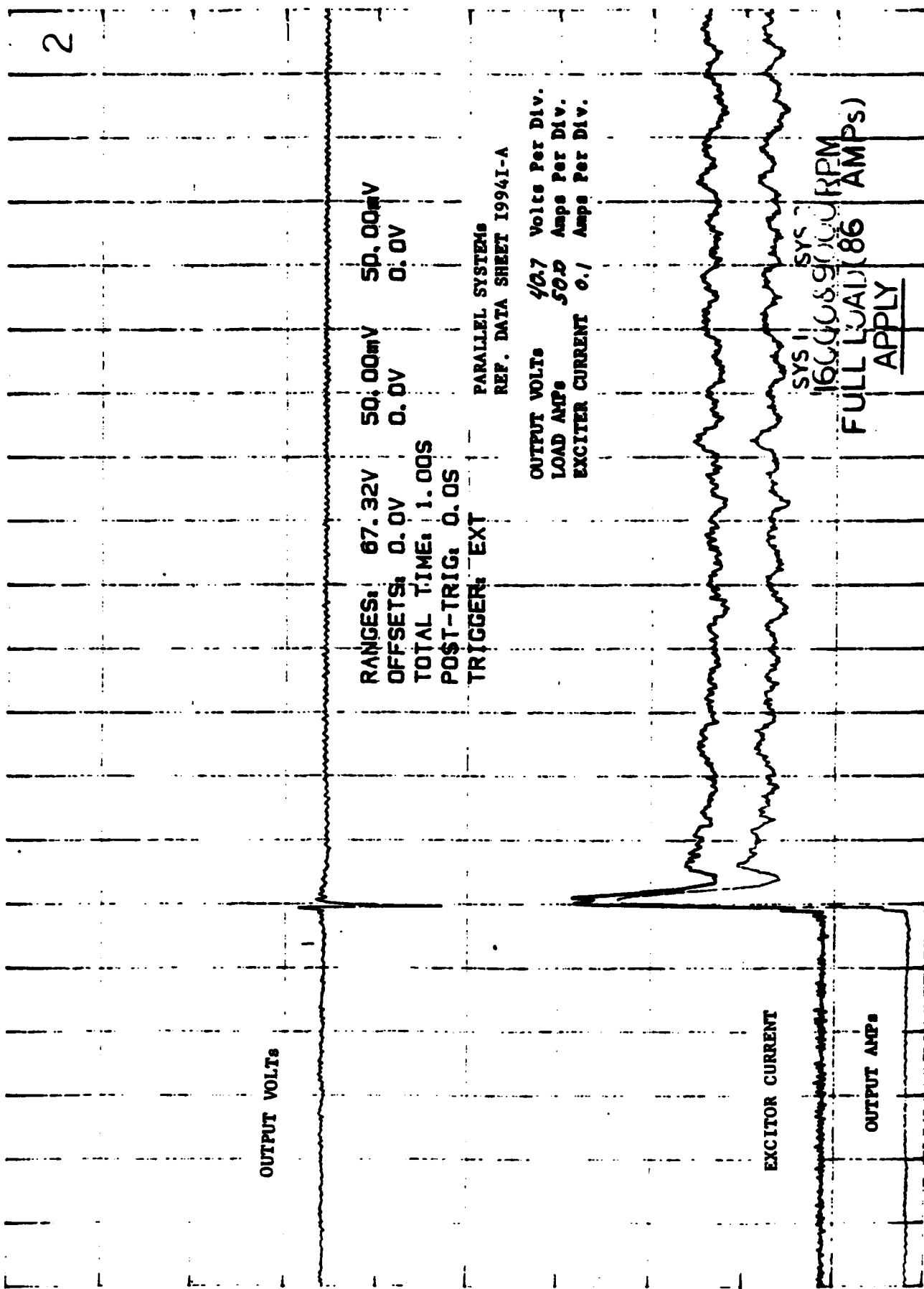
PARALLEL SYSTEMS
 REF. DATA SHEET 19941-A

OUTPUT VOLTS 40.7 Volts Per Div.
 LOAD AMPs 50.0 Amps Per Div.
 EXCITER CURRENT 0.1 Amps Per Div.

EXCITER CURRENT

OUTPUT AMPs

SYS 1
 1600089100 RPM
 FULL LOAD (86 AMPs)
 APPLY



OUTPUT VOLTS

SYS 1
16000 & 9000 RPM
2/3 LCAD (60 AMPS)
REMOVE

RANGES: 67.30V 50.00mV 50.00mV
OFFSETS: 0.0V 0.0V 0.0V
TOTAL TIME: 1.00S
POST-TRIG: 0.0S
TRIGGER: EXT

PARALLEL SYSTEMS
REF. DATA SHEET 19941-A

OUTPUT VOLTS 40.7 Volts Per Div.
LOAD AMPS 50.0 Amps Per Div.
EXCITER CURRENT 0.1 Amps Per Div.

EXCITER CURRENT

OUTPUT AMPS

4

OUTPUT VOLTS

RANGES: 67.32V 50.00mV 50.00mV
OFFSETS: 0.0V 0.0V 0.0V

TOTAL TIME: 1.00S
POST-TRIG: 0.0S
TRIGGER: EXT

PARALLEL SYSTEMS
REF. DATA SHEET 19941-A

OUTPUT VOLTS 40.7 Volts Per Div.
LOAD AMPS 50.0 Amps Per Div.
EXCITER CURRENT 0.1 Amps Per Div.

SYS 1 SYS 2
16000 & 9000 RPM
2/3 LOAD (6 AMPL)
APPLY

EXCITOR CURRENT

OUTPUT AMPS

OUTPUT VOLTS

RANGES: 67.30V 50.00mV 50.00mV
 OFFSETS: 0.0V 0.0V 0.0V
 TOTAL TIME: 1.00S
 POST-TRIG: 0.0S
 TRIGGER: EXT

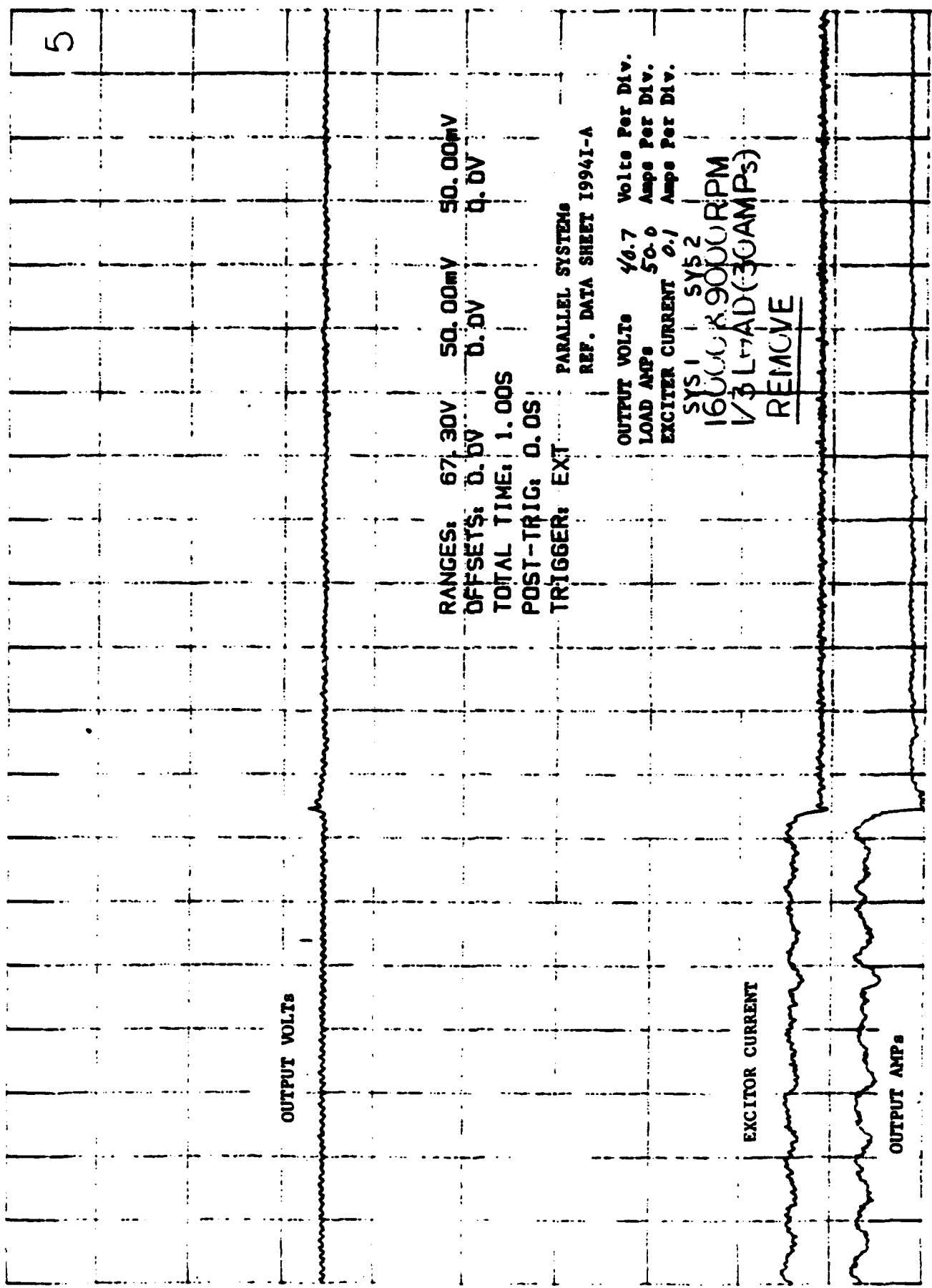
PARALLEL SYSTEMS
 REF. DATA SHEET 19941-A

OUTPUT VOLTS 40.7 Volts Per Div.
 LOAD AMPS 50.0 Amps Per Div.
 EXCITER CURRENT 0.1 Amps Per Div.

SYS 1 SYS 2
 16000 & 9000 RPM
 1/3 LOAD (30 AMPS)
REMOVE

EXCITER CURRENT

OUTPUT AMPS



OUTPUT VOLTS

RANGES: 67.32V 50.00mV 50.00mV
 OFFSETS: 0.0V 0.0V 0.0V
 TOTAL TIME: 1.00S
 POST-TRIG: 0.0S
 TRIGGER: EXT

PARALLEL SYSTEMS
 REF. DATA SHEET 19941-A

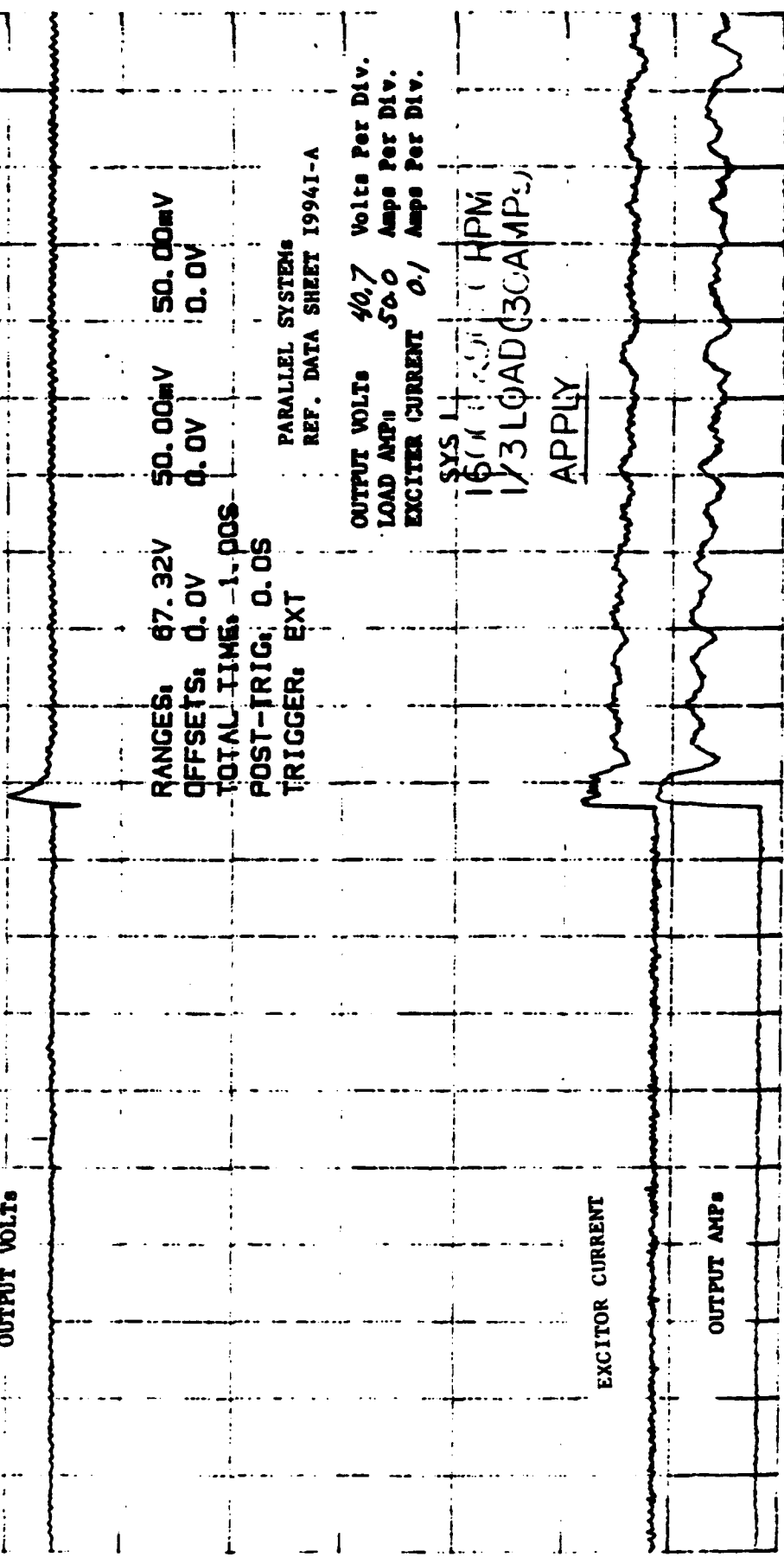
OUTPUT VOLTS 40.7 Volts Per Div.
 LOAD AMPs 50.0 Amps Per Div.
 EXCITER CURRENT 0.1 Amps Per Div.

SYS 1
 16 (1/3) HPM
 1/3 LOAD (30 AMPs)

APPLY

EXCITOR CURRENT

OUTPUT AMPs



EXPERIMENTAL LABORATORY TEST RECORD

COG. ENGR. HARMATI/kenlik
ROTOR NO. 326

MODEL NO. SYSTEM 11 SERIAL NO. GEN 101 / CURRENT 123

W.O. 54805

DATE OF TEST 7/14/88 TEST LETTER: NO. QP387 TESTED BY R.J. SANIUX

IRUSH GRADE

BAR. PRESSURE

M.P. AIR GAP

I.P. AIR GAP

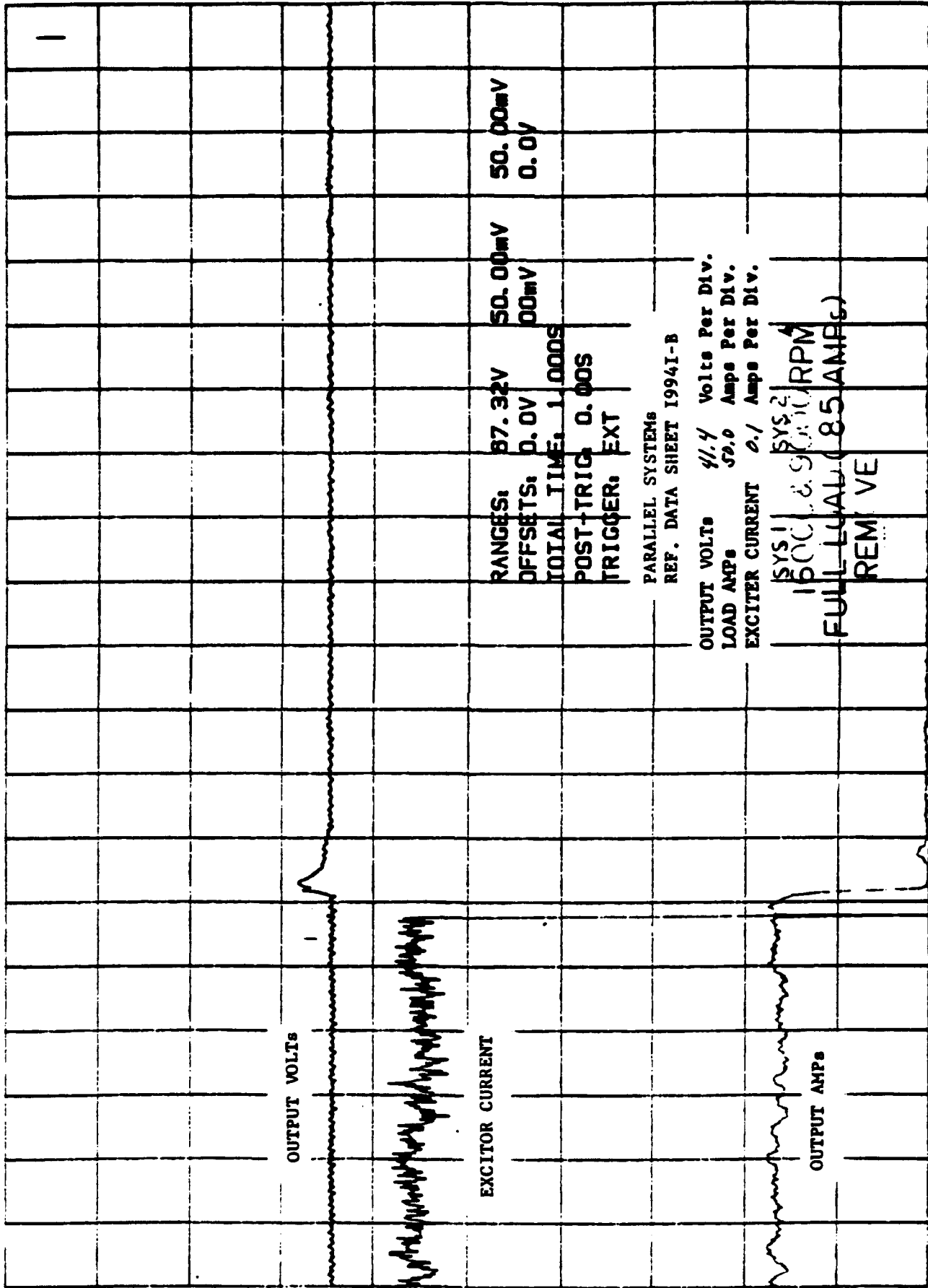
FILE: 447 "B" PARALLEL SYSTEMS

TIME	GEN	OUT VOLT	OUT AMP	EXCITER AMP	EXCITER VOLT	IN OIL	OUT OIL	STATOR #1	STATOR #2	CASE	GEAR BOX	IN OIL PRESSURE	OUT OIL PRESSURE	GAL PER MIN	RIPPLE	PAGE	OF
RPM																	
6050	1345	97.9	266.1	88	0.29	52.0	116.6	148.6	215.1	288.5	44.2	133.8	6.0	10	575	3.33	-
6000	1400	99.4	266.1	87	0.29	53.0	123.6	158.7	255.2	293.8	157.0	111.0	6.0	10	585	3.39	-
5900	1405	99.1	266.2	88	0.29	53.0	124.0	168.8	235.9	234.5	152.5	142.6	6.0	10	688	3.4	-
5850	1410	100.4	266.3	88	0.29	53.0	124.2	158.1	236.2	234.7	154.8	142.2	6.0	10	585	3.39	-
6050	1415	100.0	266.2	87	0.29	53.0	124.0	159.1	236.1	234.6	153.3	142.5	6.0	10	585	3.35	-
2100	1418	99.4	265.4	85	0.55	102.0	116.1	146.7	230.0	270.7	146.7	155.2	5.0	20	460	2.66	-
2000	1421	100.0	267.5	54	0.29	55.0	110.2	137.7	191.7	201.6	137.8	126.1	5.0	20	450	2.60	-
2000	1425	99.4	265.6	85	0.55	98.0	106.3	133.1	201.5	199.0	135.3	121.4	5.0	20	440	2.55	-
2000	1431	100.0	265.4	57	0.435	76.0	107.0	133.9	193.6	194.7	134.8	122.5	5.0	20	435	2.52	-
2000	1434	99.7	267.4	54	0.305	52.0	106.4	132.4	186.9	188.5	132.8	121.5	5.0	20	435	2.52	-
1100	1439	99.0	265.3	57	0.425	72.0	103.2	127.5	171.3	170.2	127.9	117.8	5.0	20	430	2.49	-
1000	1444	98.8	266.1	25	0.38	63.0	103.2	127.3	166.6	167.7	128.1	117.8	4.0	20	420	2.43	-
2250	1448	98.4	267.5	54	0.32	53.0	102.2	125.6	161.3	161.6	126.8	116.1	4.0	20	420	2.43	-
1500	1453	97.9	266.1	25	0.37	62.0	100.9	123.6	155.7	155.3	123.7	114.8	4.0	20	410	2.43	-
1950	1458	99.7	266.4	90	0.3	52.0	100.5	130.2	195.2	194.2	124.6	124.6	6.0	10	550	3.18	-

PRECEDING

FOLLOWING

65



OUTPUT VOLTS

EXCITOR. CURRENT

OUTPUT AMPS

RANGES: 67.32V 50.00mV 50.00mV
 OFFSETS: 0.0V 00mV 0.0V
 TOTAL TIME: 1.000S
 POST-TRIG: 0.00S
 TRIGGER: EXT

PARALLEL SYSTEMS
 REF. DATA SHEET 19941-B

OUTPUT VOLTS 41.4 Volts Per Div.
 LOAD AMPS 57.0 Amps Per Div.
 EXCITER CURRENT 0.1 Amps Per Div.

SYS 1
 1800 RPM
 FULL LOAD (35 AMPS)
 APPLY

OUTPUT VOLTS

EXCITOR CURRENT

OUTPUT AMPS

PARALLEL SYSTEMS
REF. DATA SHEET 1994I-B

OUTPUT VOLTS 4.4 Volts Per Div.
LOAD AMPS 50.0 Amps Per Div.
EXCITER CURRENT 0.1 Amps Per Div.

SYS 1 1600 6.89 (111 RPM)
SYS 2 2/3 LOAD (57 AMPs)

REMOVE

RANGES: 67.32V 50.00mV 50.00mV
OFFSETS: 0.0V 00mV 0.0V

TOTAL TIME: 1.000S

POST-TRIG: 0.00S
TRIGGER: EXT

4

RANGES: 67.32V 50.00mV 50.00mV
OFFSETS: 0.0V 0.0V 0.0V
TOTAL TIME: 1.000S
POST-TRIG: 0.00S
TRIGGER: EXT

OUTPUT VOLTS

EXCITOR CURRENT

OUTPUT AMPs

PARALLEL SYSTEMS
REF. DATA SHEET 19941-B

OUTPUT VOLTS 41.4 Volts Per Div.
LOAD AMPs 50.0 Amps Per Div.
EXCITER CURRENT 0.1 Amps Per Div.

SYS 1 SYS 2
1600 19000 RPM
2/3 LQAD (57 AMPs)
A11LY

OUTPUT VOLTS

RANGES: 87.32V 50.00mV 50.00mV

OFFSETS: 8.0V 88mV 8.0V

TOTAL TIME: 1.000S

POST-TRIG: 0.00S

TRIGGER: EXT

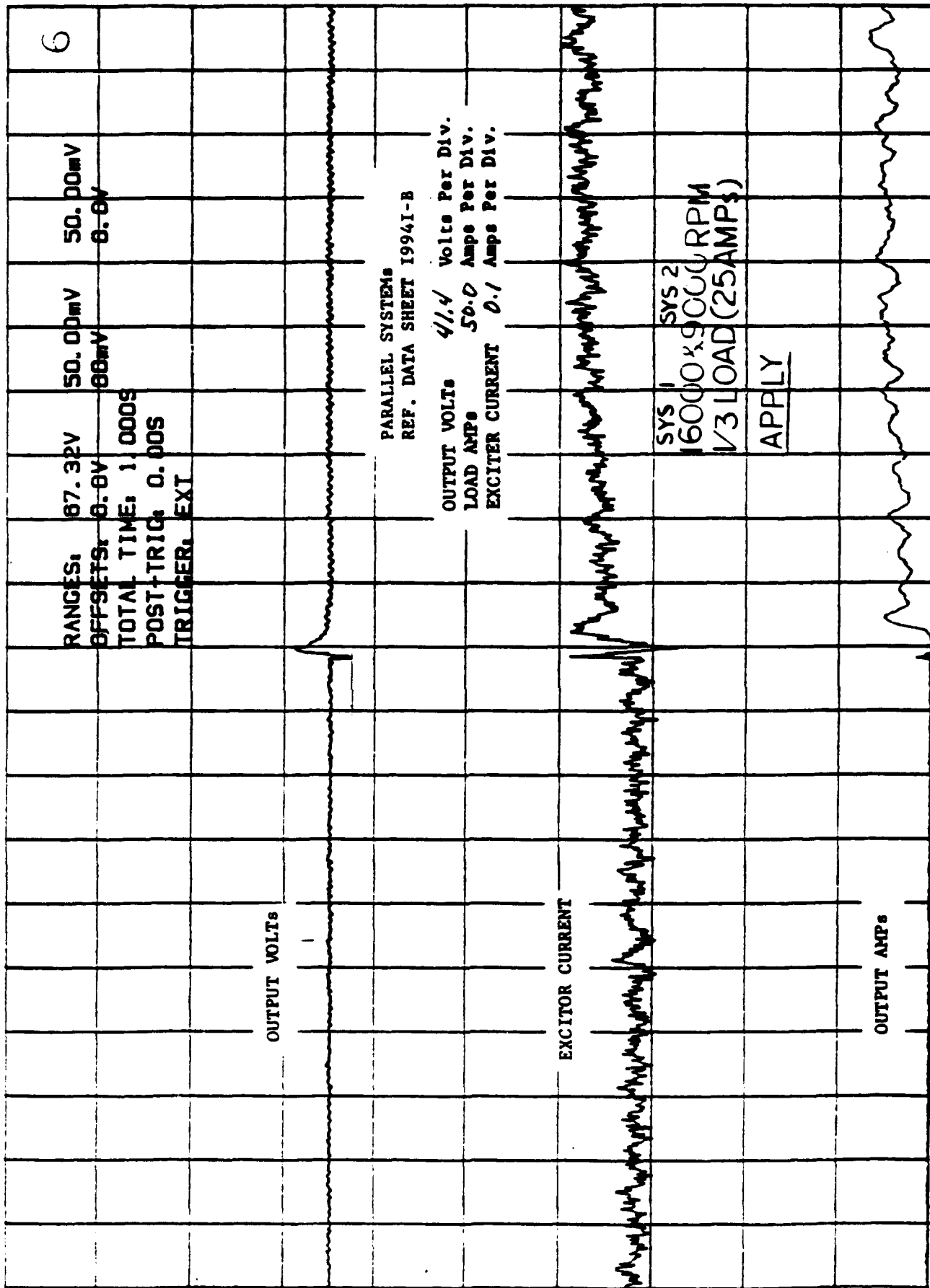
PARALLEL SYSTEMS
REF. DATA SHEET 19941-B

OUTPUT VOLTS 41.4 Volts Per Div.
LOAD AMPS 50.0 Amps Per Div.
EXCITER CURRENT 0.1 Amps Per Div.

EXCITER CURRENT

OUTPUT AMPS

SYS 1 SYS 2
16000 & 9000 RPM
V3 LOAD (25 AMP)
REMOVE



LEULOU DEMOSPHERE
POWER EQUIPMENT CORP.

EXPERIMENTAL LABORATORY TEST RECORD

COG. ENGR. HARMATHA CLK

MODEL NO. SYSTEM 1

TEST LETTER: NO. QP 387

DATE OF TEST 7/15/88

STATOR NO.

ROTOR NO.

TESTED BY R. J. SANIUK

IRISH GRADE

BAR. PRESSURE

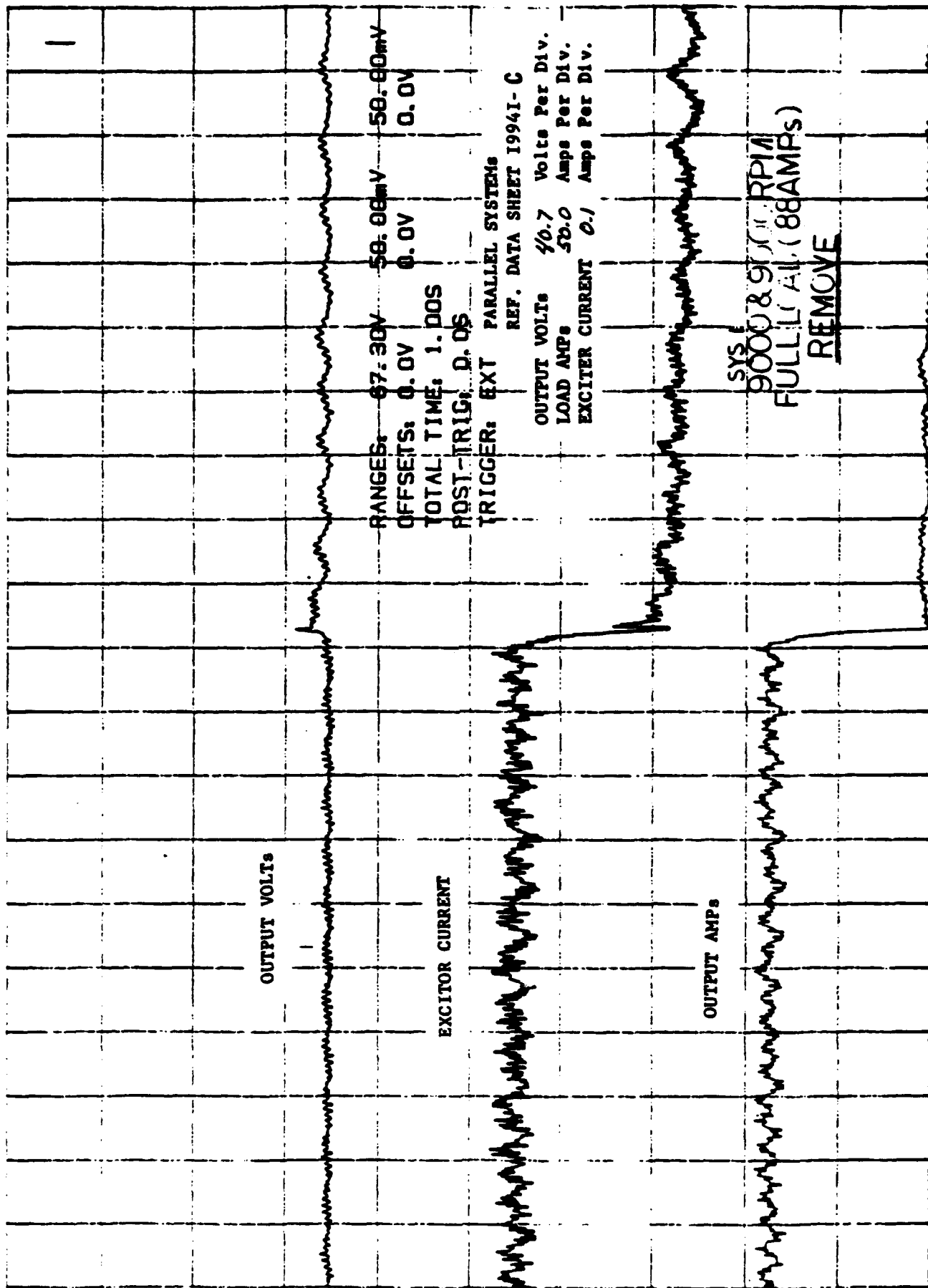
M.P. AIR GAP

I.P. AIR GAP

TITLE: <u>4.2.3 "C" PARALLEL SYSTEMS</u>										9000 & 9000 RPM										PAGE		OF
RPM	TIME	GEN	VOLT	AMP	EXCITER	IN	OUT	OIL	STATOR	CASE	BEAR BOX	IN	OUT	OIL	PER	RIPPLE	+	-	NO.			
6050	1340	98.0	266.4	86	124	42	97.1	127.8	206.0	210.5	126.0	121.7	8.5	14.5	555	321	2.0	2.1	-			
6050	1345	103.5	266.4	87	124	43	98.9	131.1	220.5	224.5	130.2	134.5	8.5	14.0	555	321	2.0	2.2	-			
6050	1350	103.2	266.4	87	124	43	99.4	133.0	218.8	223.6	131.1	135.6	8.5	14.0	555	321	2.0	2.2	-			
6050	1355	103.6	266.4	87	124	43.5	101.2	133.4	220.5	225.5	132.2	136.5	8.5	14.0	560	324	2.0	2.1	-			
6050	1400	101.9	266.4	87	124	43.5	101.6	133.6	221.7	227.1	133.1	137.2	8.5	14.0	560	324	2.0	2.1	-			
7050	1404	103.5	265.2	88	124	44	93.9	126.3	221.5	228.9	133.3	130.2	10.0	13.5	366	2.11	4.2	4.0	-			
7050	1406	103.5	267.5	88	124	45.0	93.2	122.5	192.9	196.7	125.3	117.5	12.0	15.5	360	2.08	4.0	4.0	1			
7050	1410	103.0	266.1	88	124	45.1	90.6	117.8	185.9	192.0	119.0	113.8	14.0	18.0	355	2.06	4.2	4.0	2			
7050	1413	102.7	265.5	86	124	45.6	90.6	118.7	194.5	198.7	120.3	114.1	14.4	18.0	350	2.03	4.2	4.2	-			
7050	1416	105.6	268.0	54	124	45.6	90.5	117.8	182.0	186.0	119.2	113.5	14.0	18.0	355	2.06	4.0	4.0	3			
7050	1423	103.1	266.5	56	124	45.5	89.5	114.0	166.4	170.5	114.8	110.8	15.0	18.0	350	2.03	4.5	4.0	4			
7050	1427	103.9	266.4	27	124	48	89.8	114.4	163.6	166.5	115.1	110.9	15.0	19.0	355	2.06	4.0	4.0	-			
7050	1434	105.2	268.6	54	124	48.2	89.8	113.8	157.9	160.3	114.8	110.9	14.5	19.0	355	2.06	4.0	4.0	5			
7050	1438	102.6	266.2	27	124	48.5	89.3	112.4	151.8	154.4	112.6	109.7	15.0	19.0	360	2.08	4.0	4.0	6			

PRECEDING

FOLLOWING



OUTPUT VOLTS

RANGES: 67.30V 50.00mV 50.00mV
 OFFSETS: 0.0V 0.0V 0.0V
 TOTAL TIME: 1.00S
 POST-TRIG: 0.0S
 TRIGGER: EXT

PARALLEL SYSTEMS
 REF. DATA SHEET 19941- C

OUTPUT VOLTS 40.7 Volts Per Div.
 LOAD AMPS 50.0 Amps Per Div.
 EXCITER CURRENT 0.1 Amps Per Div.

EXCITER CURRENT

OUTPUT AMP

SYST SYS
 9000 9000 K/M
 FULLY AD (88AMP)
 APPLY

OUTPUT VOLTS

EXCITOR CURRENT

OUTPUT AMPS

RANGES: 67.30V 50.00mV 50.00mV
OFFSETS: 0.0V 8.0V 8.0V

TOTAL TIME: 1.00S
POST-TRIG: 0.0S
TRIGGER: EXT

PARALLEL SYSTEMS
REF. DATA SHEET 1994I-C

OUTPUT VOLTS 40.7 Volts Per Div.
LOAD AMPS 50.0 Amps Per Div.
EXCITER CURRENT 0.1 Amps Per Div.

SYS1 SYS2
9000.8900(L REM
2/3 LOAD(56AMPS)
IREM:VE

PARALLEL SYSTEMS
REF. DATA SHEET 19941-C

OUTPUT VOLTS 40.7 Volts Per Div.
LOAD AMPS 50.0 Amps Per Div.
EXCITER CURRENT 0.1 Amps Per Div.

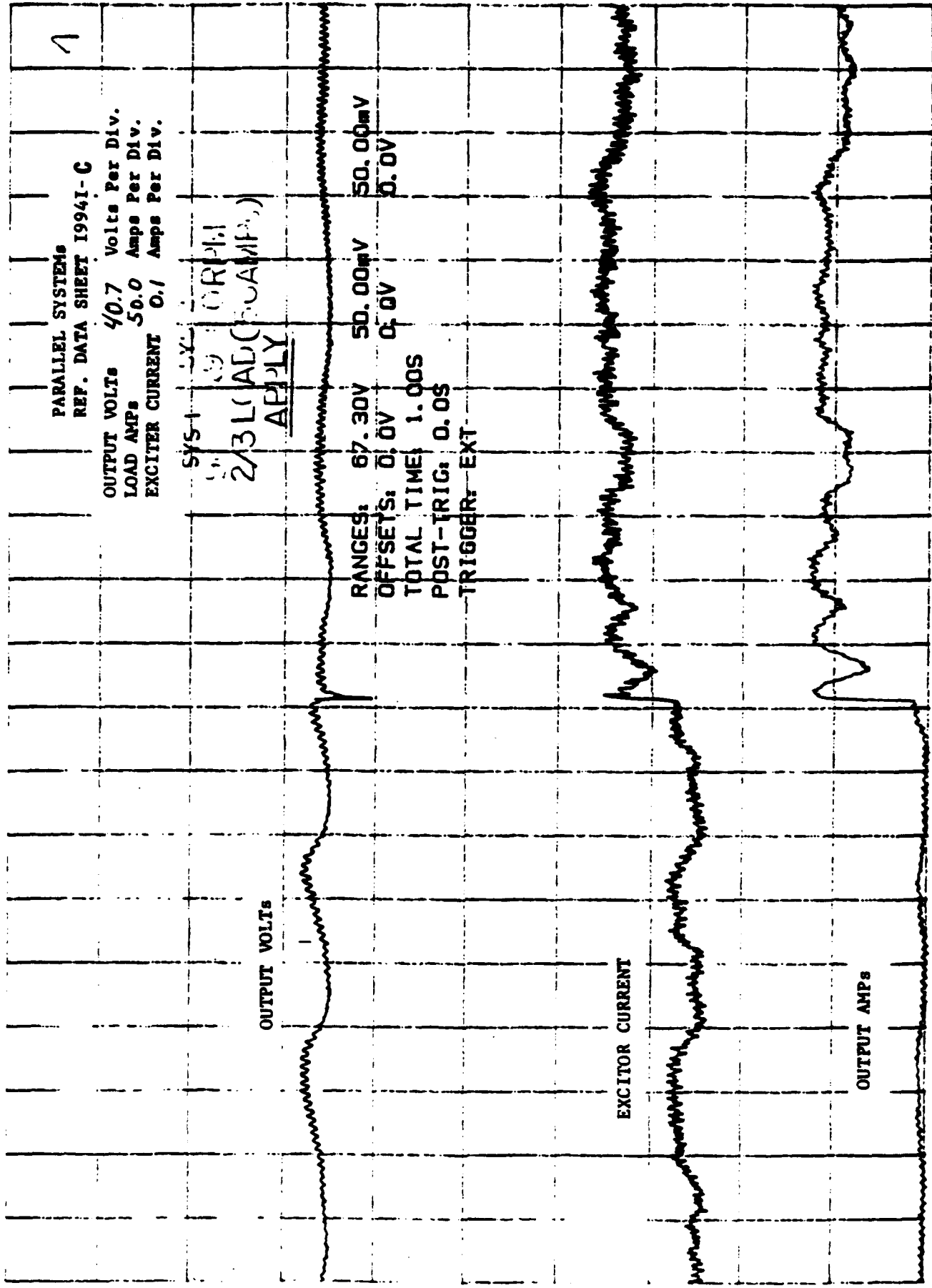
SYS 1
2/3 L (AD (50 AMP))
APPLY

RANGES: 67.30V 50.00mV 50.00mV
OFFSETS: 0.0V 0.0V 0.0V
TOTAL TIME: 1.00S
POST-TRIG: 0.0S
TRIGGER: EXT

OUTPUT VOLTS

EXCITER CURRENT

OUTPUT AMPS



OUTPUT VOLTS

PARALLEL SYSTEMS
REF. DATA SHEET 1994 - C

OUTPUT VOLTS 40.7 Volts Per Div.
LOAD AMPS 50.0 Amps Per Div.
EXCITER CURRENT 0.1 Amps Per Div.

SYS 1 SYS 2
900 RPM
V3LL AD (2/AMPS)
REMOVE

EXCITOR CURRENT

OUTPUT AMPS

RANGES: 67.30V 50.00mV 50.00mV
OFFSETS: 0.0V 0.0V 0.0V
TOTAL TIME: 1.00S
POST-TRIG: 0.0S
TRIGGER: EXT

OUTPUT VOLTS

PARALLEL SYSTEMS
REF. DATA SHEET 19941-C

OUTPUT VOLTS 40.7 Volts Per Div.
LOAD AMPS 50.0 Amps Per Div.
EXCITER CURRENT 0.1 Amps Per Div.

5751 9000 RPM
V3L (AT (27AMPS))

APPLY

EXCITOR CURRENT

OUTPUT AMPS

RANGES: 67.30V
OFFSETS: 0.0V
TOTAL TIME: 1.00S
POST-TRIG: 0.0S
TRIGGER: EXT

50.00mV
0.0V

50.00mV

0.0V

EXPERIMENTAL LABORATORY TEST RECORD

MODEL NO. SYSTEM II SERIAL NO. GEN 101 / CURRENT 123 / DISCHARGE 124

COG. ENGR. *HARMATLICK*
ROTOR NO. STATOR NO.

W.O. 54805

DATE OF TEST 7/15/88

TEST LETTER: NO. QP387

TESTED BY R.J. SANIUK

BRUSH GRADE

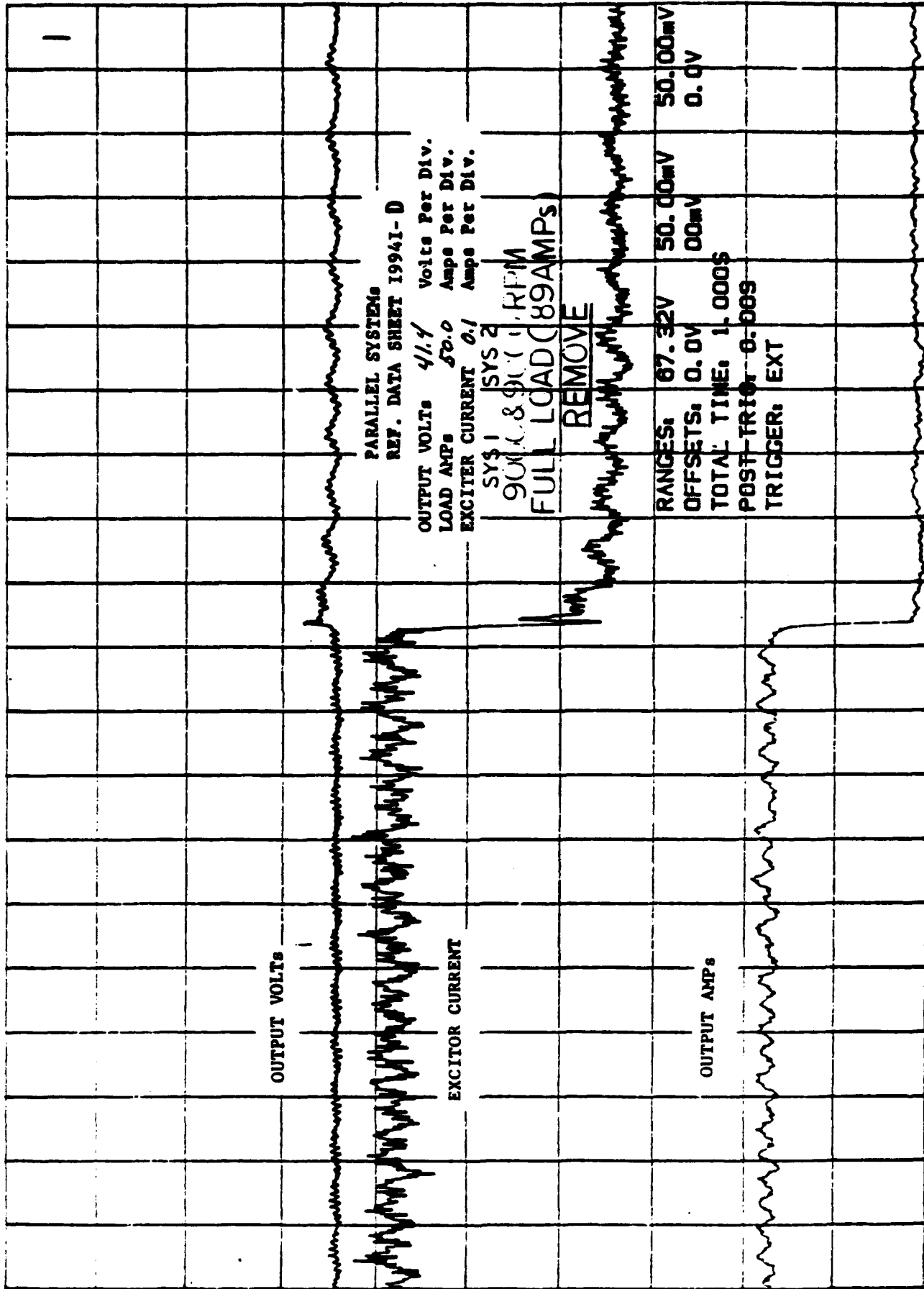
BAR. PRESSURE

M.P. AIR GAP

I.P. AIR GAP

TITLE: 4.53 "C" PARALLEL SYSTEMS 9000 & 9000 RPM

TIME	GEN	OUT VOLT	OUT AMP	EXCITER	IN	OUT #1	STATOR #2	GEAR BOX	IN	OUT PRESSURE	OIL	GAL PER MIN	RIPPLE	PAGE	OF
RPM	GEN	VOLT	AMP	AMP	IN	OUT	STATOR	CASE	IN	OUT	OIL	MIN	+	-	NO.
1840	98.0	266.3	89	2.295	57.5	119.2	153.9	221.4	150.0	188.5	6.0	10	560	3.24	-
1845	103.5	266.2	89	0.295	54.0	123.8	157.2	233.4	153.9	141.1	6.0	10.5	590	3.42	-
1850	103.2	266.3	89	0.295	54.0	123.7	158.7	238.4	155.0	141.6	6.0	10.5	590	3.42	-
1855	103.6	266.2	89	0.295	54.0	124.6	159.5	239.1	155.2	142.5	6.0	10.5	585	3.39	-
1900	101.9	266.3	89	0.295	55.0	124.9	159.7	239.7	155.2	142.6	6.0	10.5	585	3.37	-
1904	103.5	265.4	89	0.57	107.5	141.6	144.8	233.3	147.3	132.4	6.0	9.0	460	2.66	-
1906	103.5	267.4	5.1A	0.34	66.0	111.6	139.9	203.7	140.8	142.5	5.0	9.0	450	2.61	-
1910	103.0	266.0	89	0.57	101	106.0	132.4	122.8	187.4	135.9	4.5	8.5	445	2.58	-
1913	102.7	265.8	56	0.47	83.0	106.9	134.0	206.2	140.9	137.4	4.5	8.5	415	2.53	-
1916	105.6	269.1	54	0.35	60.5	106.3	132.7	190.8	151.1	136.0	4.5	8.5	435	2.52	-
1923	108.1	266.0	57	0.47	81.0	103.0	127.5	175.4	173.3	131.6	4.5	8.5	435	2.52	-
1927	103.9	266.3	29	0.39	66.0	103.7	128.5	173.0	174.3	132.0	4.5	8.5	435	2.52	-
1930	105.2	268.8	5.1A	0.35	60.0	103.4	127.5	167.0	168.1	130.8	4.5	8.5	435	2.52	-
1933	102.6	266.0	29	0.385	64.5	101.9	125.5	160.2	157.8	128.5	4.5	8.0	435	2.52	-



OUTPUT VOLTS

RANGES: 67.32V 50.00mV
OFFSETS: 0.0V 0.0V
TOTAL TIME: 1.000S
POST-IRIG: 0.00S
TRIGGER: EXT

EXCITOR CURRENT

OUTPUT AMPs

PARALLEL SYSTEMS
REF. DATA SHEET 19941-D

OUTPUT VOLTS 41.4 Volts Per Div.
LOAD AMPs 50.0 Amps Per Div.
EXCITER CURRENT 0.1 Amps Per Div.

SRS SYS2
9000 & 9000 RPM
FULL LOAD (89 AMPs)
APPLY

OUTPUT VOLTS

EXCITOR CURRENT

OUTPUT AMPS

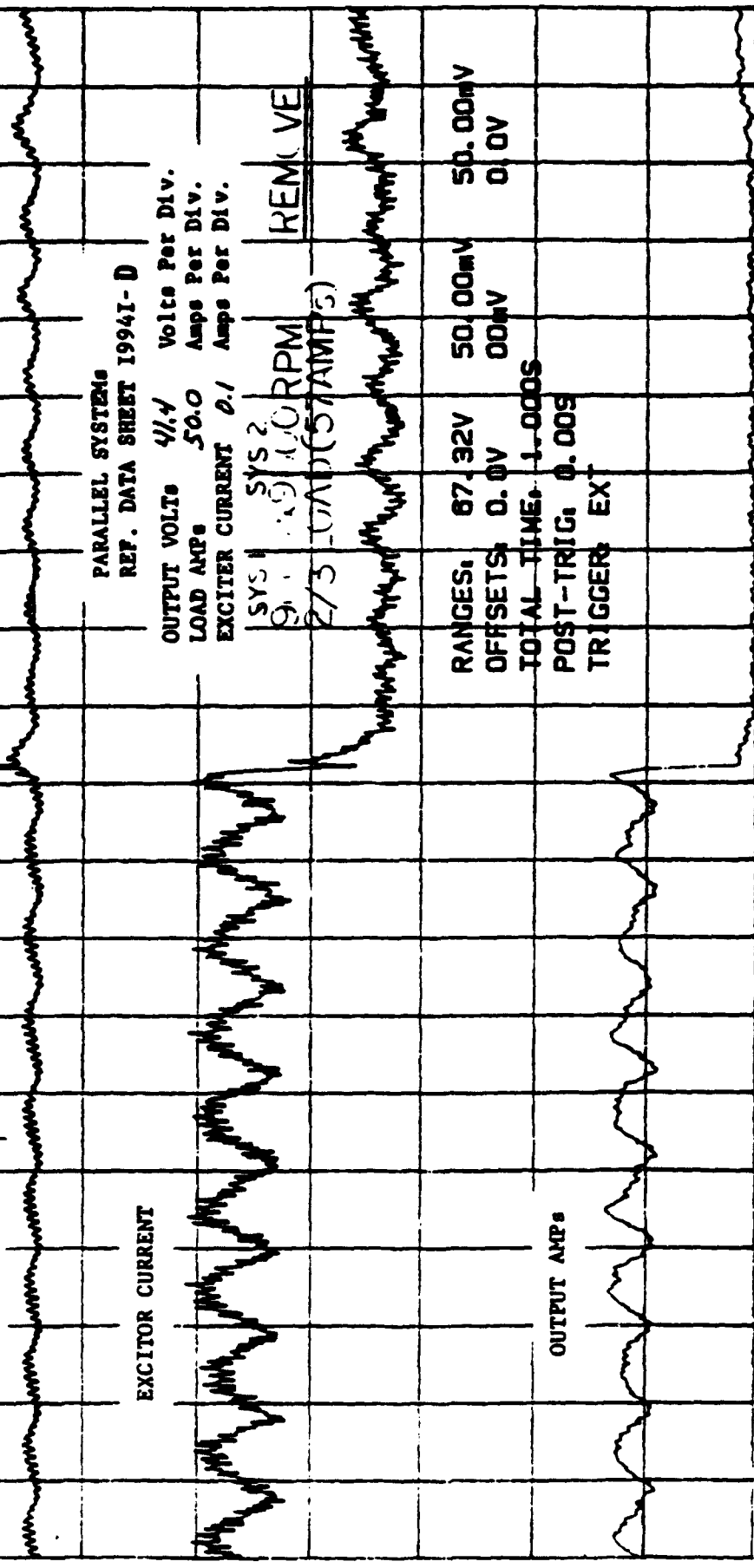
PARALLEL SYSTEMS
REF. DATA SHEET 1994I-D

OUTPUT VOLTS 4/4 Volts Per Div.
LOAD AMPS 50.0 Amps Per Div.
EXCITER CURRENT 0.1 Amps Per Div.

SYS 1
9.1 10.0 RPM
2/3 LOAD (57 AMPS)

REMOVE

RANGES: 87.32V 50.00mV 50.00mV
OFFSETS: 0.0V 00mV 0.0V
TOTAL TIME: 1.000S
POST-TRIG: 0.00S
TRIGGER: EXT



PARALLEL SYSTEMS

REF. DATA SHEET 19941- D

OUTPUT VOLTS 4/4 Volts Per Div.
 LOAD AMPs 50.0 Amps Per Div.
 EXCITER CURRENT 0.1 Amps Per Div.

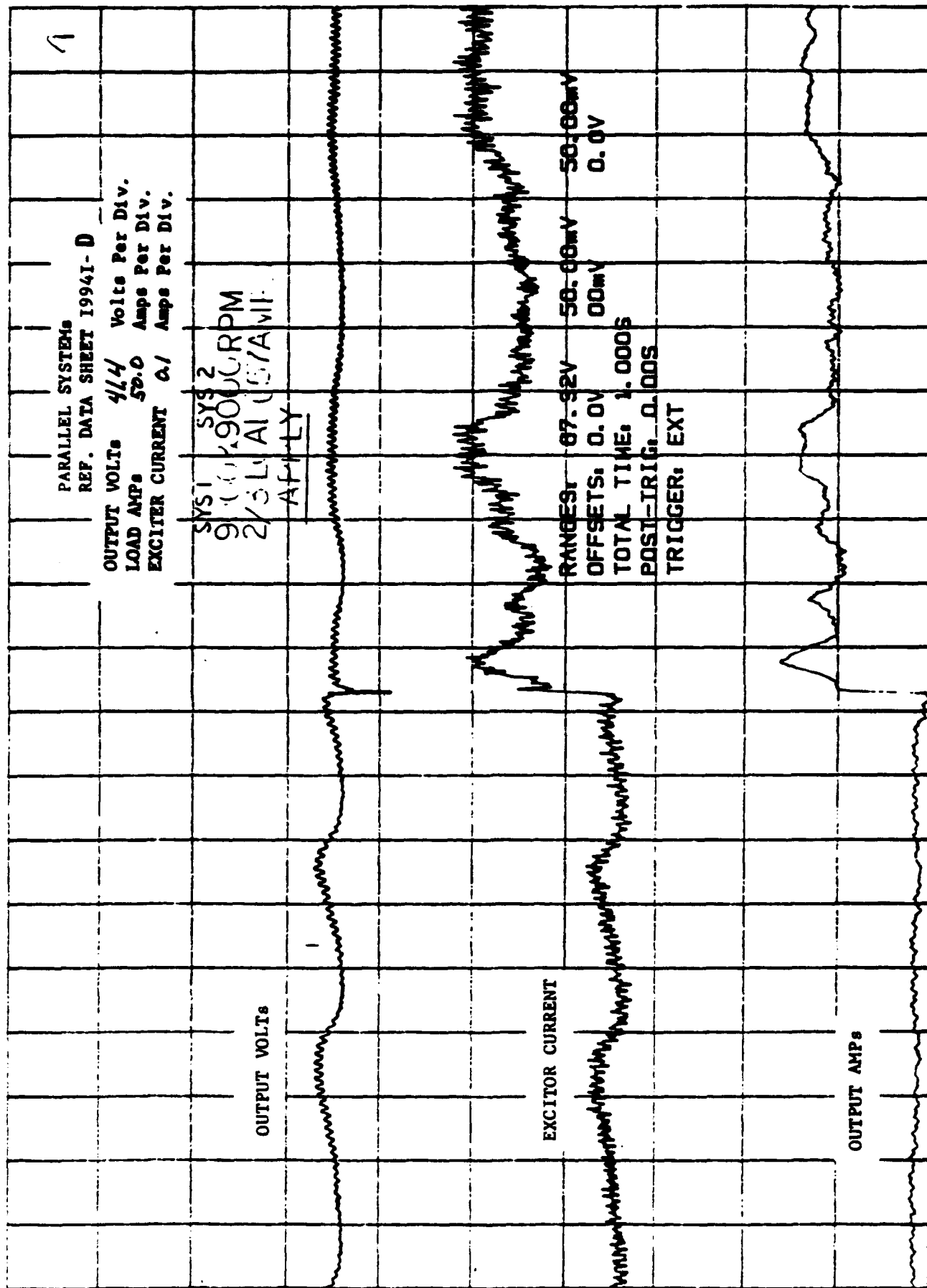
SYS1 SYS2
 900K900RPM
 2/3 L1 AL (5/A) II
 APPLY

OUTPUT VOLTS

EXCITOR CURRENT

OUTPUT AMPs

RANGES: 07.32V 50.00mV 50.00mV
 OFFSETS: 0.0V 00mV 0.0V
 TOTAL TIME: 1.000S
 POST-TRIG: 0.00S
 TRIGGER: EXT



OUTPUT VOLTS



EXCITOR CURRENT



OUTPUT AMPS

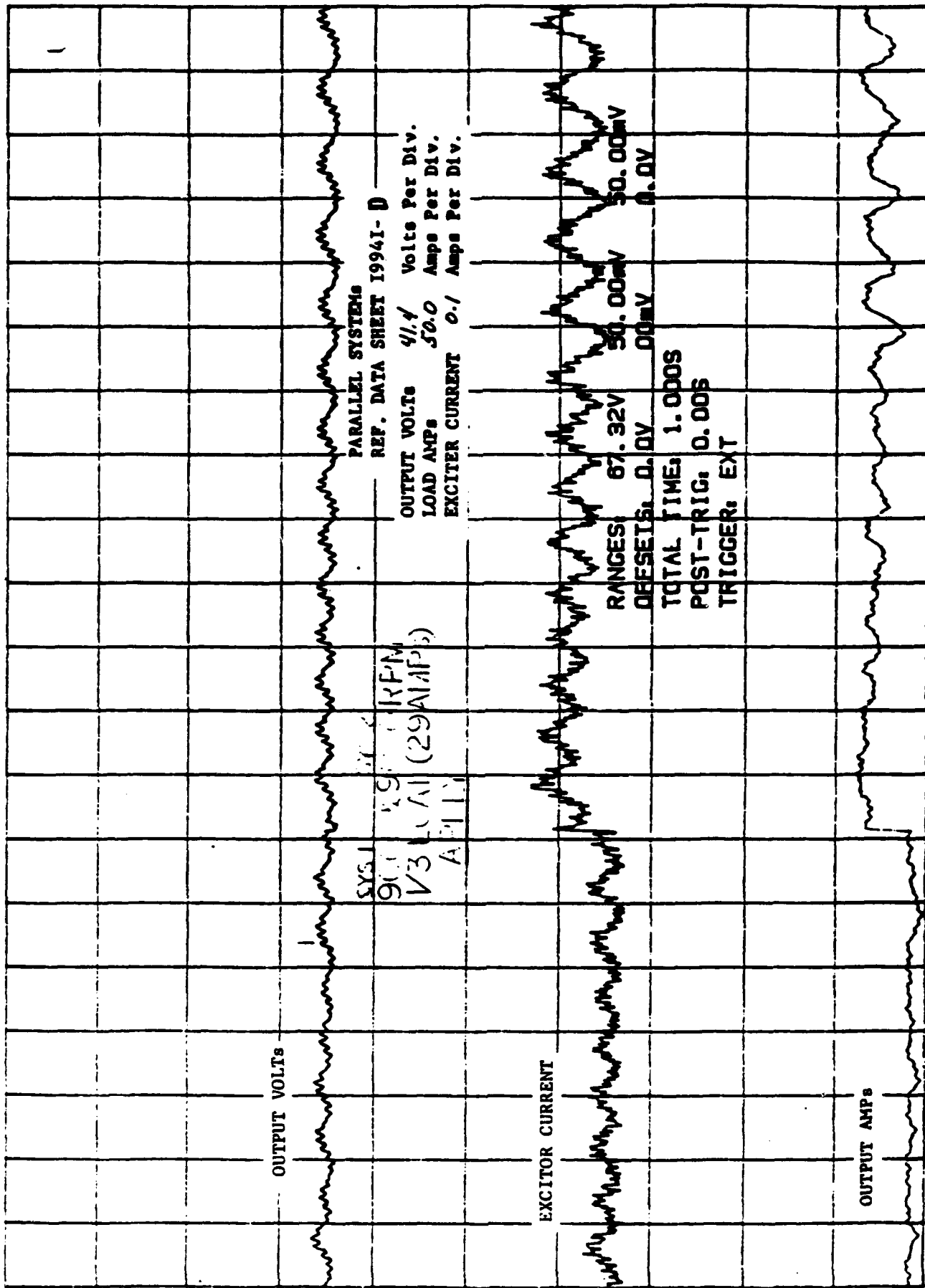


PARALLEL SYSTEMS
REF. DATA SHEET 19941-D
OUTPUT VOLTS 4.4 Volts Per Div.
LOAD AMPS 50.0 Amps Per Div.
EXCITER CURRENT 0.1 Amps Per Div.

SYS 1
29.00RPM
1/3 LOAD (29Amps)

REMOVE

RANGES: 67.32V 50.00mV 50.00mV
OFFSETS: 0.0V 00mV 0.0V
TOTAL TIME: 1.000S
POST-TRIG: 0.00S
TRIGGER: EXT



EXPERIMENTAL LABORATORY TEST RECORD
CURRENT
SWITCH

COG. ENGR. HARMA, Verluk
ROTOR NO. _____ STATOR NO. _____

E.W.O. 54805

MODEL NO. SYSTEM 1 SERIAL NO. GEN

DATE OF TEST 7/21/88

TEST LETTER: NO. QP387

TESTED BY R.J. SANIUK

BRUSH GRADE _____

BAR. PRESSURE _____

M.P. AIR GAP _____

I.P. AIR GAP _____

TITLE: 4.9.3 "C" PARALLEL SYSTEMS 9000 & 18000 RPM

DATE: 4.2.5		PARALLEL SYSTEMS										9000 & 18000 RPM										PAGE		OF	
RPM	TIME	AMB. TEMP.	OUTPUT		EXCITER	OIL	STARTER		GEAR BOX	IN	OUT	OIL PRESSURE	OIL	GAL PER MIN	RIPPLE	-	NO.								
			VOLT	AMP			#1	#2										CASE							

OUTPUT VOLTS

RANGES: 67.30V 50.00mV 50.00mV
OFFSETS: 0.0V 0.0V 0.0V
TOTAL TIME: 1.00S
POST-TRIG: 0.0S
TRIGGER: EXT

PARALLEL SYSTEMS

REF. DATA SHEET 19941-E

OUTPUT VOLTS 40.7 Volts Per Div.
LOAD AMPS 60.0 Amps Per Div.
EXCITER CURRENT 0.1 Amps Per Div.

EXCITOR CURRENT

SYS 1 SYS 2

18000 & 9000 RPM

FULLY AT (90A111)

REMOVE

OUTPUT AMPS

OUTPUT VOLTS

RANGES: 67.30V 50.00mV 50.00mV
 OFFSETS: 0.0V 0.0V 0.0V
 TOTAL TIME: 1.00S
 POST-TRIG: 0.0S
 TRIGGER: EXT

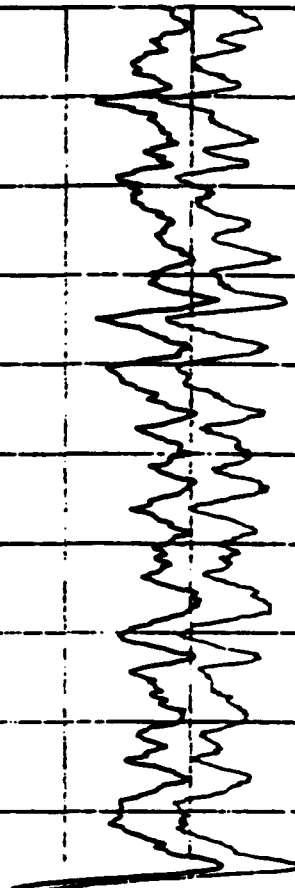
PARALLEL SYSTEMS
 REF. DATA SHEET 19941-E
 OUTPUT VOLTS 42.7 Volts Per Div.
 LOAD AMPS 37.0 Amps Per Div.
 EXCITER CURRENT 0.1 Amps Per Div.

SYS1 SYS2
 18000 & 9000 RPM
 FULL LOAD (90AMPS)

APPLY

EXCITOR CURRENT

OUTPUT AMPS



OUTPUT VOLTS

RANGES: 67.30V 50.00mV 50.00mV
OFFSETS: 0.0V 0.0V 0.0V

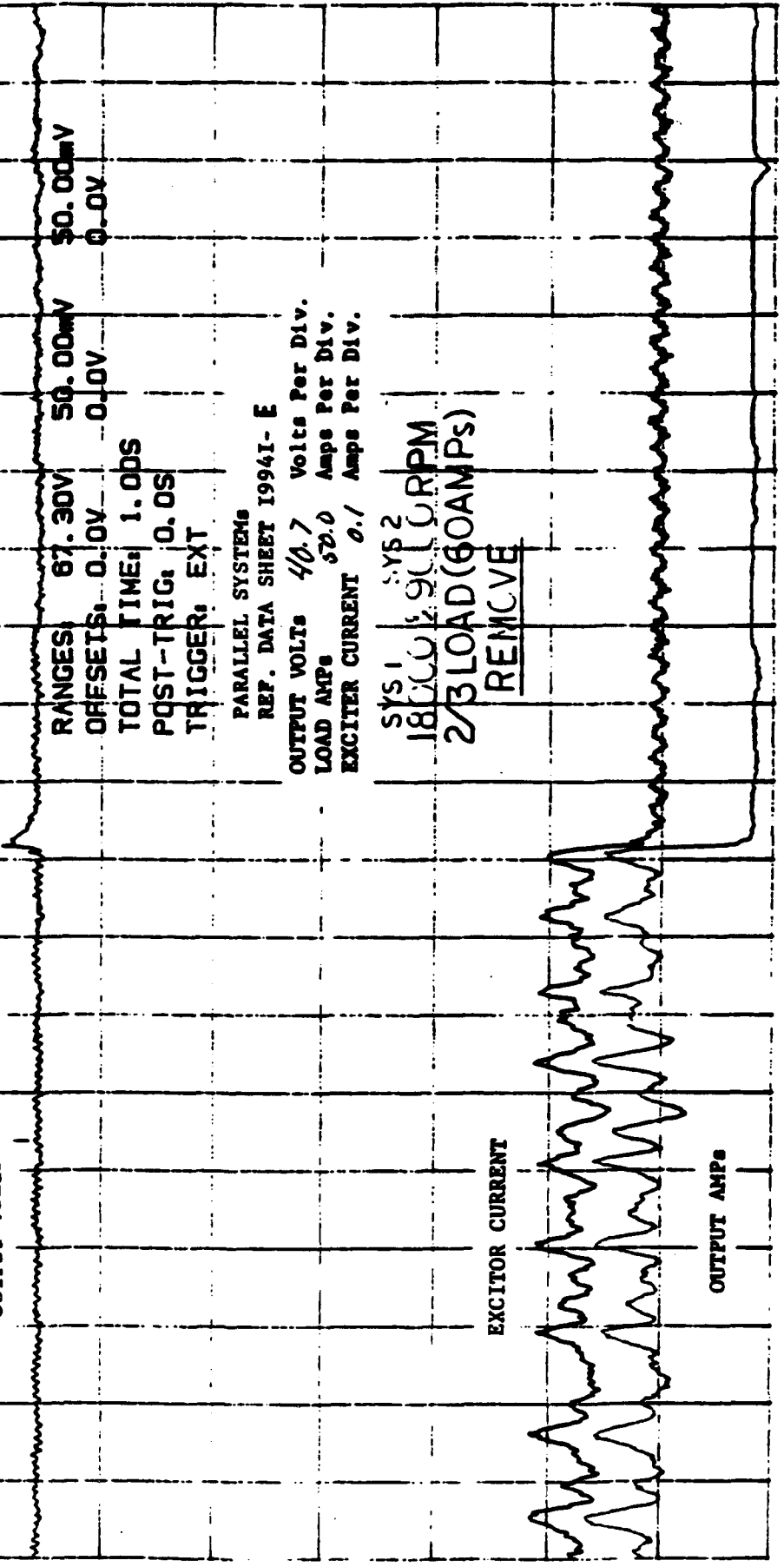
TOTAL TIME: 1.00S
POST-TRIG: 0.0S
TRIGGER: EXT

PARALLEL SYSTEMS
REF. DATA SHEET 19941- E
OUTPUT VOLTS 40.7 Volts Per Div.
LOAD AMPs 50.0 Amps Per Div.
EXCITER CURRENT 0.1 Amps Per Div.

SYS 1 SYS 2
18000 1900 RPM
2/3 LOAD (60 AMPS)
REMCVE

EXCITOR CURRENT

OUTPUT AMPs



1

OUTPUT VOLTS

RANGES: 67.30V 50.00mV 50.00mV
OFFSETS: 0.0V 0.0V 0.0V

TOTAL TIME: 1.00S
POST-TRIG: 0.0S
TRIGGER: EXT

PARALLEL SYSTEMS
REF. DATA SHEET 19941-E

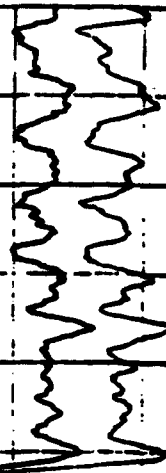
OUTPUT VOLTS 40.7 Volts Per Div.
LOAD AMPS 50.0 Amps Per Div.
EXCITER CURRENT 0.1 Amps Per Div.

SYS 1
18-11-15 (11-15 RPT)
2/3 LCAI (60 AMPS)

APPLY

EXCITER CURRENT

OUTPUT AMPS



OUTPUT VOLTS

RANGES: 67.30V 50.00mV 50.00mV
 OFFSETS: 0.0V 0.0V 0.0V
 TOTAL TIME: 1.00S
 POST-TRIG: 0.0S
 TRIGGER: EXT

PARALLEL SYSTEMS
 REF. DATA SHEET 19941-E

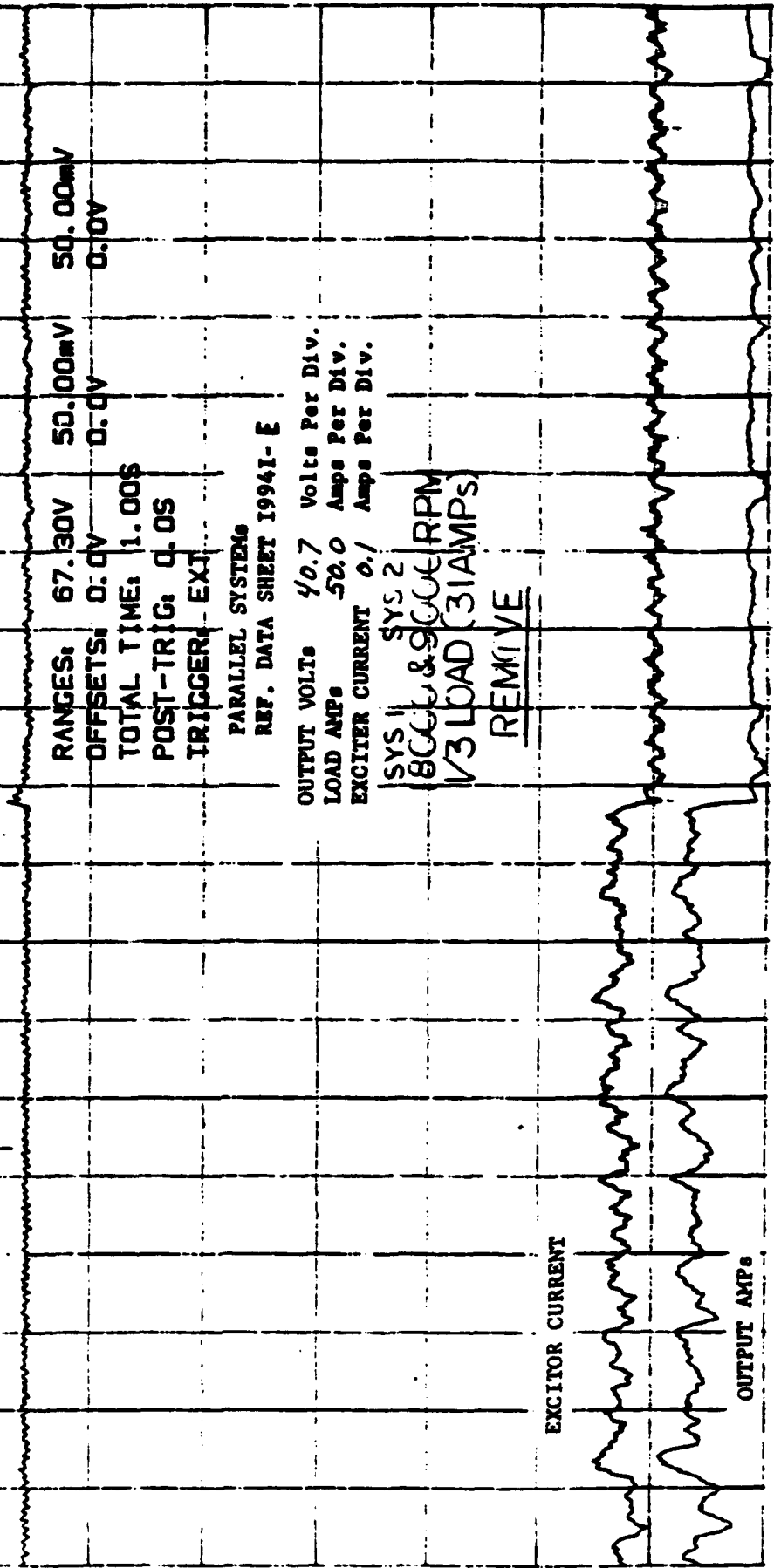
OUTPUT VOLTS 40.7 Volts Per Div.
 LOAD AMPS 50.0 Amps Per Div.
 EXCITOR CURRENT 0.1 Amps Per Div.

SYS II SYS 2
 8000 & 9000 RPM
 1/3 LOAD (31AMPS)

REMOVE

EXCITOR CURRENT

OUTPUT AMPS



OUTPUT VOLTS

RANGES: 67.30V 50.00mV 50.00mV
 OFFSETS: 0.0V 0.0V 0.0V

TOTAL TIME: 1.00S
 POST-TRIG: 0.0S
 TRIGGER: EXT

PARALLEL SYSTEMS

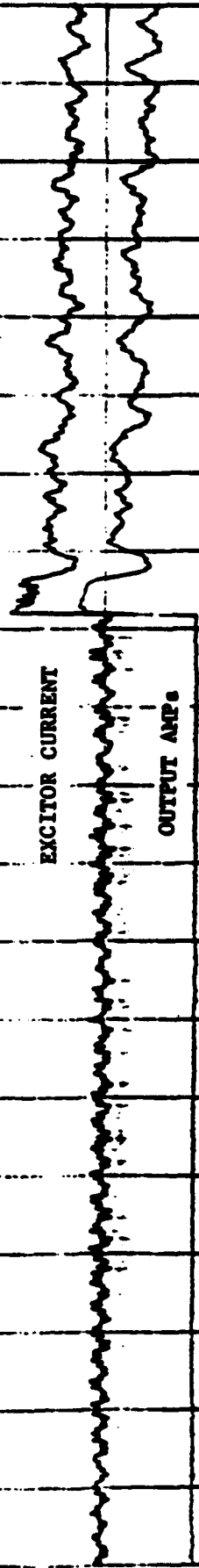
REF. DATA SHEET 19941-F

OUTPUT VOLTS 40.7 Volts Per Div.
 LOAD AMPS 50.0 Amps Per Div.
 EXCITER CURRENT 0.1 Amps Per Div.

SYS I
 1800 1900 RPM
 V3 LOAD (31 AMPS)
 APPLY

EXCITER CURRENT

OUTPUT AMPS



OUTPUT VOLTS

RANGES: 87.32V 50.00mV 50.00mV
OFFSETS: 0.0V 00mV 0.0V

TOTAL TIME: 1.000S
POST-TRIG: 0.00S
TRIGGER: EXT

EXCITOR CURRENT

PARALLEL SYSTEMS

REF. DATA SHEET 19941-F

OUTPUT VOLTS 41.4 Volts Per Div.
LOAD AMPS 50.0 Amps Per Div.
EXCITER CURRENT 0.1 Amps Per Div.

18000 & 91.0 CRPM
1/3 LOAD (27AMP)
APPLY

OUTPUT AMPS

Parallel Shutdown

Purpose: The purpose of this test was to verify the capability of system protection to properly operate in the event of shutdown of one system during parallel operation.

Procedure and Results: Two systems (I and II) were operated in parallel at 16,000 rpm with rated load (167 amperes) until temperatures stabilized. The load was reduced to 100 amperes and system II shutdown. Data was recorded on LAPEC data sheet 20899 and charts 20899-A and 20899-B. The two systems were again connected in parallel at no load and system II was shutdown. Data was recorded on LAPEC data sheet 20899 and charts 20899-C and 20899-D.

Discussion of Results: The test results show that upon shutdown of system II, system I assumed the total load as required.

RANGES: 67.32V 50.00mV 5.000V
 OFFSETS: 0.0V 0.0V 0.0V
 TOTAL TIME: 10.00S
 PRE-TRIG: 0.50S
 TRIGGER: EXT

OUTPUT VOLTS 24.7 Volts Per Div.
 LOAD AMPs 24.3 Amps Per Div.
 EXCITER CURRENT .16 Amps Per Div.

SYSTEM II

OUTPUT VOLTS

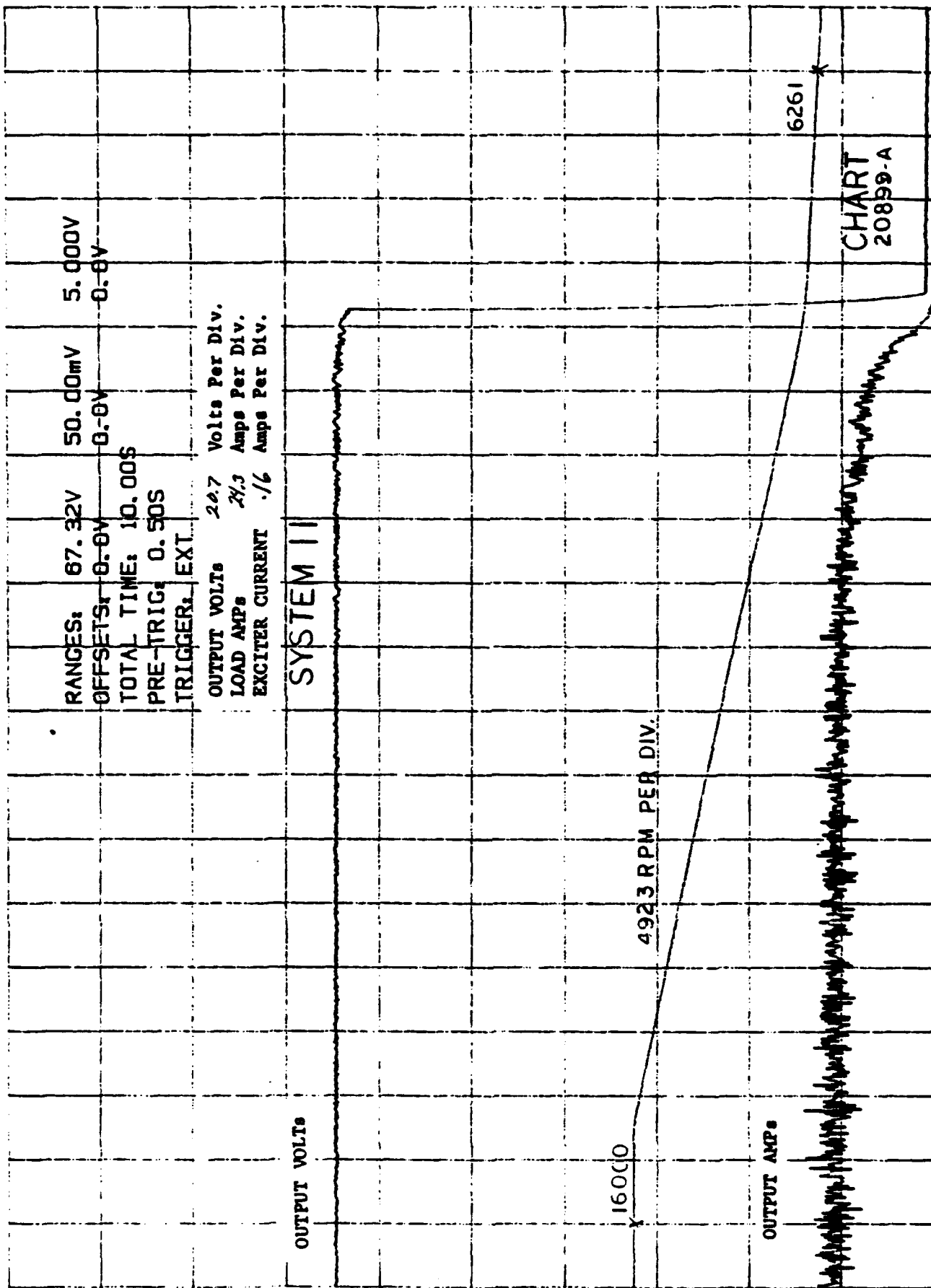
16000

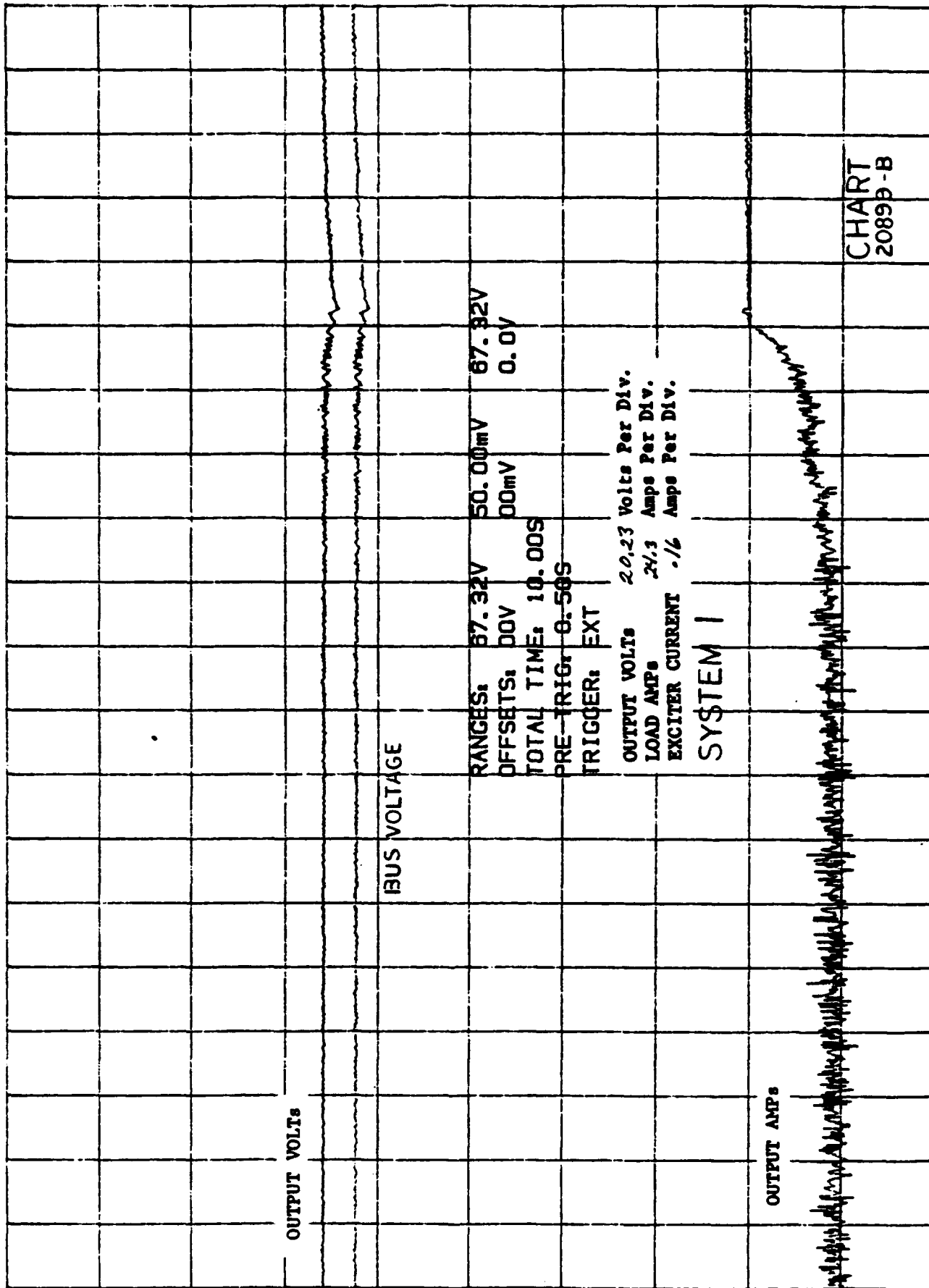
4923 RPM PER DIV.

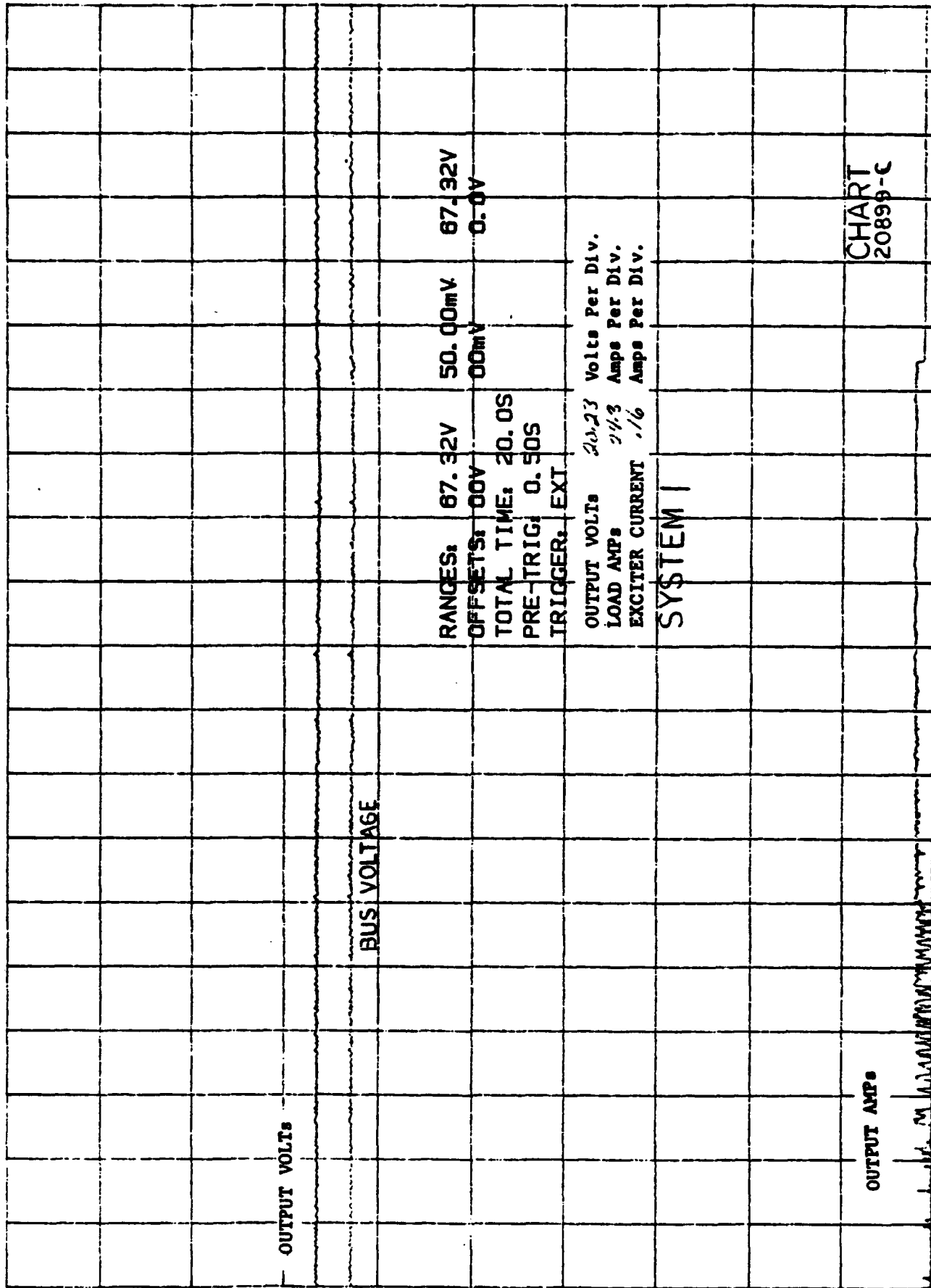
OUTPUT AMPs

6261

CHART
 20899-A







OUTPUT VOLTS

OUTPUT AMPS

RANGES: 67.32V 50.00mV 5.000V
OFFSETS: 0.0V 0.0V 0.0V
TOTAL TIME: 20.0S
PRE-TRIG: 0.50S
TRIGGER: EXT
OUTPUT VOLTS 20.7 Volts Per Div.
LOAD AMPS 24.3 Amps Per Div.
EXCITER CURRENT 16 Amps Per Div.

SYSTEM III

16000

492.3 RPM PER DIV.

6260

X

CHART
20899-D

Parallel Load Division

Purpose: The purpose of these tests was to demonstrate that two parallel systems shared load within 10% of a single channel rating with voltage maintained within specification regulation limits.

Procedure: Two distinct tests were performed. Prior to each of these tests, the paralleled systems were operated at rated load on each system (334 amperes total) and the generator speeds at 16,000 rpm. The following tests were performed:

1. The two parallel systems were operated concurrently at rated load (334 amperes) over the speed range from 9,000 rpm to 18,000 rpm on 1,000 rpm increments.
2. With the two paralleled systems operating at full load, the speed of system I was set at 10,000 rpm and the speed of system II varied from 18,000 rpm to 10,000 rpm in 1,000 rpm increments.

Results: Test results were recorded on data sheets 19942-A, 19942-B, 19942-C, 19942-D.

Discussion of Results: The test data indicates, that the two parallel system shared load within 3 amperes (2% of full load rating) when the two generators were operating at the same speeds and when one generator speed was varied with one other held constant, the maximum load sharing differential current did not exceed 6 amperes (4% of full load rating)

EXPERIMENTAL LABORATORY TEST RECORD

COG. ENGR. HARMA, PERLUX

SERIAL NO. GEN 121 / CURRENT 121

MODEL NO. SYSTEM 1

E.W.O. 54805

DATE OF TEST 7/22/88 TEST LETTER: NO. QP 387 TESTED BY R.J. SANIUK

BRUSH GRADE _____ BAR. PRESSURE _____ M.P. AIR GAP _____ I.P. AIR GAP _____

TITLE: 4, 11 A-1 PARALLEL LOAD DIVISION																PAGE	OF
TIME	GEN. TEMP.	OUT VOLT	EXCIT. AMP	EXCIT. VOLT	OIL IN	OIL OUT	STATOR #1	CASE #2	BEAR BOX	IN. OIL	OUT. OIL	GAL. PER MIN.	R.P.M.	CHART	NO.		
RPM	GEN	VOLT	AMP	VOLT	IN	OUT	#1	#2	CASE	BOX	IN	OUT	MIN				
16000	1306	269.5	167	0.41	80.0	96.5	172.5	297.5	308.5	120.8	141.5	9.0	15.0	555	3.2	3.8	
18000	1311	269.5	167	0.40	80.0	103.2	145.5	370.5	370.5	132.3	123.7	10.0	15.0	585	3.39	3.0	
12050	1314	268.2	167	0.40	81.5	104.8	149.2	378.6	378.6	136.7	127.1	9.8	15.0	580	3.39	4.0	
16050	1316	268.8	167	0.41	83.0	104.7	148.9	381.1	381.1	137.3	127.2	9.0	14.5	565	3.27	3.0	
15050	1319	268.7	167	0.42	84.5	103.2	147.4	386.3	386.3	136.2	125.8	8.5	14.2	555	3.2	3.4	
14050	1322	268.5	166	0.46	87.0	101.8	144.7	385.4	385.4	134.6	124.1	8.0	14.0	530	3.07	3.2	
13050	1325	268.5	167	0.49	99.0	100.2	142.9	384.5	384.5	133.9	123.5	8.0	13.9	510	2.95	4.0	
12050	1329	268.3	167	0.52	103.5	98.7	141.7	384.4	384.4	132.5	121.7	8.0	13.0	475	2.75	4.0	
11050	1331	267.9	167	0.50	119.0	97.4	141.5	386.4	386.4	133.1	122.4	8.0	12.5	440	2.55	4.0	
10050	1333	267.2	167	0.68	142.0	95.4	141.6	391.7	407.5	132.8	121.4	10.0	14.0	390	2.26	4.0	
9050	1335	262.2	170	0.96	210.4	93.7	143.8	406.7	421.3	133.6	121.2	12.0	15.0	345	1.99	4.2	
16000	1338	268.7	168	0.49	88	105.5	151.1	406.4	417.5	139.2	127.5	14.0	21.5	660	3.24	3.0	

E.W.O. 54805
MODEL NO. SYSTEM 11
TEST LETTER NO. QP 387
DATE OF TEST 7/22/88
EXPERIMENTAL LABORATORY TEST RECORD
SERIAL NO. 6 EN 101 / 123
COG. ENGR. HARMAN, PERLUX
ROTOR NO. 116
STATOR NO.

TESTED BY R.J. SANIUK

BRUSH GRADE										M.P. AIR GAP										I.P. AIR GAP									
TITLE: 4/11 A-1 PARALLEL LOAD DIVISION																													
TIME	GEN	OUT VOLT	OUT AMP	EXCITER	IN	OUT	STATOR	CASE	BEAR	IN	OUT	OL PRESSURE	OIL	PUR	GAL	RIPPLE	PAGE	OF											
RPM	GEN	VOLT	AMP	VALT	IN	OUT	#1	#2	BOX	IN	OUT	IN	OUT	MIN	PER	+	-	NO.											
1306	93.8	268.9	168	0.465	85.0	118.1	158.6	316.0	301.1	153.7	141.9	6.0	10.5	570	3.45														
1800	91.7	268.5	167	0.442	84.0	130.5	175.7	384.5	371.6	169.3	156.5	5.5	11.0	615	3.73														
1700	95.6	268.8	168	0.443	86.5	135.7	182.8	405.6	396.5	175.5	162.8	5.5	11.0	610	3.69														
1600	95.9	268.5	167	0.432	88.0	136.1	183.6	411.5	403.7	174.8	162.2	5.5	10.0	590	3.57														
1500	96.6	268.4	167	0.44	92.0	144.1	179.8	412.0	405.6	173.4	160.3	5.0	9.6	585	3.54														
1400	96.8	268.2	167	0.50	102.5	152.0	176.5	410.7	405.0	173.0	158.6	5.0	9.5	570	3.45														
1300	97.5	268.1	168	0.54	112.5	150.1	173.1	409.8	404.2	171.1	153.3	5.0	9.0	550	3.33														
1200	97.7	268.0	167	0.57	120	152.9	170.5	408.9	401.0	169.9	153.0	5.0	8.5	530	3.21														
1100	98.4	267.9	167	0.63	134	156.6	169.1	408.9	401.3	169.0	149.1	5.0	8.5	520	3.03														
1000	98.5	266.8	167	0.78	166	155.2	167.3	409.4	405.0	167.4	150.3	5.0	8.5	450	2.73														
900	98.7	262.1	167	1.0	218	153.6	166.0	405.4	403.8	166.4	150.7	5.0	8.5	460	2.79														
1600	98.9	268.3	168	0.57	97.5	152.7	178.2	410.8	403.3	172.5	157.4	4.0	16.0	590	3.57														

EXPERIMENTAL LABORATORY TEST RECORD

E.W.O. 54805

MODEL NO. SYSTEM 11

SERIAL NO. GEN 121 / CURRENT 123

COG. ENGR. HARMAN, JEROLD

ROTOR NO.

STATOR NO.

DATE OF TEST

7/23/88

TEST LETTER: NO. GP 387

TESTED BY R.J. SANIUX

BRUSH GRADE

BAR. PRESSURE

M.P. AIR GAP

I.P. AIR GAP

TITLE: 4.11 A-2 PARALLEL LOAD DIVISION

TIME	AMP. TEMP.	OUT PUT	EXCITER	IN	OUT #1	STATOR #2	CASE	GEAR BOX	IN	OUT	OIL PRESSURE	OIL PER	RIPPLE	PAGE	OF
RPM	GEN	VOLT	AMP	VALT.	IN	OUT #1	STATOR #2	CASE	GEAR BOX	IN	OUT	OIL PER	RIPPLE	PAGE	OF
16050	99.5	268.0	167	0.49	93	121.3	159.8	338.7	321.8	159.1	141.3	5.0	10.0	565	3.93
16060	100.2	268.6	165	0.37	68	121.6	158.7	276.6	272.4	157.1	144.0	5.0	9.5	555	3.36
16000	102.2	268.5	169	0.37	69	124.9	164.0	287.4	284.0	160.7	147.4	5.0	9.5	580	3.33
16000	102.3	268.2	171	0.35	66.5	129.0	170.4	294.3	282.9	165.3	152.9	5.0	10.0	594	3.6
17060	102.6	268.1	171	0.36	69	130.1	171.5	298.7	294.9	167.0	157.3	5.0	10.0	595	3.6
15850	102.5	268.1	171	0.37	71.0	129.3	169.7	299.2	295.9	166.2	158.4	5.0	9.5	585	3.54
16000	103.2	268.1	170	0.385	76.0	127.8	167.4	297.6	294.7	164.8	150.7	5.0	9.5	555	3.16
14050	103.5	268.0	170	0.40	76.0	125.5	163.4	293.7	291.3	161.4	146.8	4.5	9.5	520	3.21
16050	103.8	268.0	170	0.425	80.0	123.4	160.2	290.6	288.3	159.0	144.3	4.5	9.5	520	3.21
16500	104.1	267.8	170	0.465	87.0	121.6	157.8	287.2	285.5	157.6	142.2	4.5	9.0	520	3.03
11050	104.7	267.6	169	0.52	92.0	119.3	154.3	284.4	282.4	154.7	139.6	4.5	6.5	485	2.94
16000	104.7	267.4	168	0.6	113	117.0	151.1	281.8	280.4	153.0	137.1	4.5	8.0	465	2.82
16000	105.0	268.5	168	0.37	69	121.0	158.2	284.4	281.5	157.2	141.5	5.0	9.5	565	3.43

Overvoltage Function Trip

Purpose: The purpose of this test was to demonstrate the effectiveness of system protection when a fault exists on one channel of a parallel system resulting in overexcitation/overvoltage condition.

Procedure: Two systems, I and II, were operated in parallel at 10,000, 16,000, and 18,000 rpm. At each of these speeds, tests were run at 0, 50, and 100% rated load with faults applied first to system I and then to system II.

Results: Test results are tabulated in Table 5-4. This table corresponds to LAPEC data sheet 20897 and accompanying charts.

Discussion of Results: Test results show correct faulty system isolation under full-load (167 amperes) condition. However, at lighter loads and no load, the sensing of the faulty system is not reliable and can lead to the loss of both systems. Just like in the case of underexcitation, (Ex: Sensing of load and exciter field current) the detection of overexcitation need to be improved to properly identify the faulty system.

TABLE 5-4OVEREXCITATION/OVERVOLTAGE FUNCTION TRIP

<u>RPM</u>	<u>Z Load</u>	<u>Syst. Faulted</u>	<u>Max. Volts</u>		<u>Chart No.</u>	
			<u>Syst. I</u>	<u>Syst. II</u>	<u>Syst. I</u>	<u>Syst. II</u>
10,000	0	I	353	355	1	1A
10,000	0	II	364	326	A	A1
16,000	0	I	424	432	1B	1C
16,000	0	II	424	433	A2	A3
18,000	0	I	421	433	1D	1E
18,000	0	II	421	433	A4	A5
10,000	50	I	335	338	2	2A
10,000	50	II	353	322	B	B1
16,000	50	I	334	342	2B	2C
16,000	50	II	343	349	B2	B3
18,000	50	I	339	347	2D	2E
18,000	50	II	423	433	B4	B5
10,000	100	I	313	313	3	3A
10,000	100	II	320	329	C	C1
16,000	100	I	338	360	3B	3C
16,000	100	II	317	342	C2	C3
18,000	100	I	311	377	3D	3E
18,000	100	II	334	372	C4	C5

EXPERIMENTAL LABORATORY TEST RECORD

MODEL NO. *54805*

SERIAL NO. *143*

TEST LETTER: NO. *QP 387*

TESTED BY *R.J. SANIUK*

DATE OF TEST *12/23/88*

COG. ENGR. *L. HARMAT*

STATOR NO. *143*

DATE OF TEST *12/23/88* TEST LETTER: NO. *QP 387* TESTED BY *R.J. SANIUK*

BRUSH GRADE				BAR. PRESSURE				M.P. AIR GAP				I.P. AIR GAP				PAGE		OF
TIME	AMP	EXCITATION	OVERVOLTAGE	FUNCTION	TRIP	CHART	NO.	CHART	NO.	CHART	NO.	CHART	NO.	CHART	NO.	CHART	NO.	
RPM	WLT	AMP	WLT	IN	OUT	#1	#2	CASE										
16000	266.3	84.3	42.0	100.0	133	216.0	222.0	122.0										
15980	266.3	85.0	43.0	124.0	159.0	236.0	235.0	155.0										
10000	FAULTED	CHART	1	100.0	133	216.0	222.0	122.0										
10010	FAULTED	CHART	1A	100.0	133	216.0	222.0	122.0										
10020	FAULTED	CHART	1B	100.0	133	216.0	222.0	122.0										
10030	FAULTED	CHART	1C	100.0	133	216.0	222.0	122.0										
10040	FAULTED	CHART	1D	100.0	133	216.0	222.0	122.0										
10050	FAULTED	CHART	1E	100.0	133	216.0	222.0	122.0										
10060	FAULTED	CHART	2	100.0	133	216.0	222.0	122.0										
10070	FAULTED	CHART	2A	100.0	133	216.0	222.0	122.0										
10080	FAULTED	CHART	2B	100.0	133	216.0	222.0	122.0										
10090	FAULTED	CHART	2C	100.0	133	216.0	222.0	122.0										
10100	FAULTED	CHART	2D	100.0	133	216.0	222.0	122.0										
10110	FAULTED	CHART	2E	100.0	133	216.0	222.0	122.0										
10120	FAULTED	CHART	3	100.0	133	216.0	222.0	122.0										
10130	FAULTED	CHART	3A	100.0	133	216.0	222.0	122.0										
10140	FAULTED	CHART	3B	100.0	133	216.0	222.0	122.0										
10150	FAULTED	CHART	3C	100.0	133	216.0	222.0	122.0										
10160	FAULTED	CHART	3D	100.0	133	216.0	222.0	122.0										
10170	FAULTED	CHART	3E	100.0	133	216.0	222.0	122.0										

OUTPUT VOLTS

RESET

RANGES: 67.32V 50.00mV 50.00mV
OFFSETS: 0.0V 0.0V 0.0V
TOTAL TIME: 10.00S
POST-TRIG: 0.0S
TRIGGER: EXT

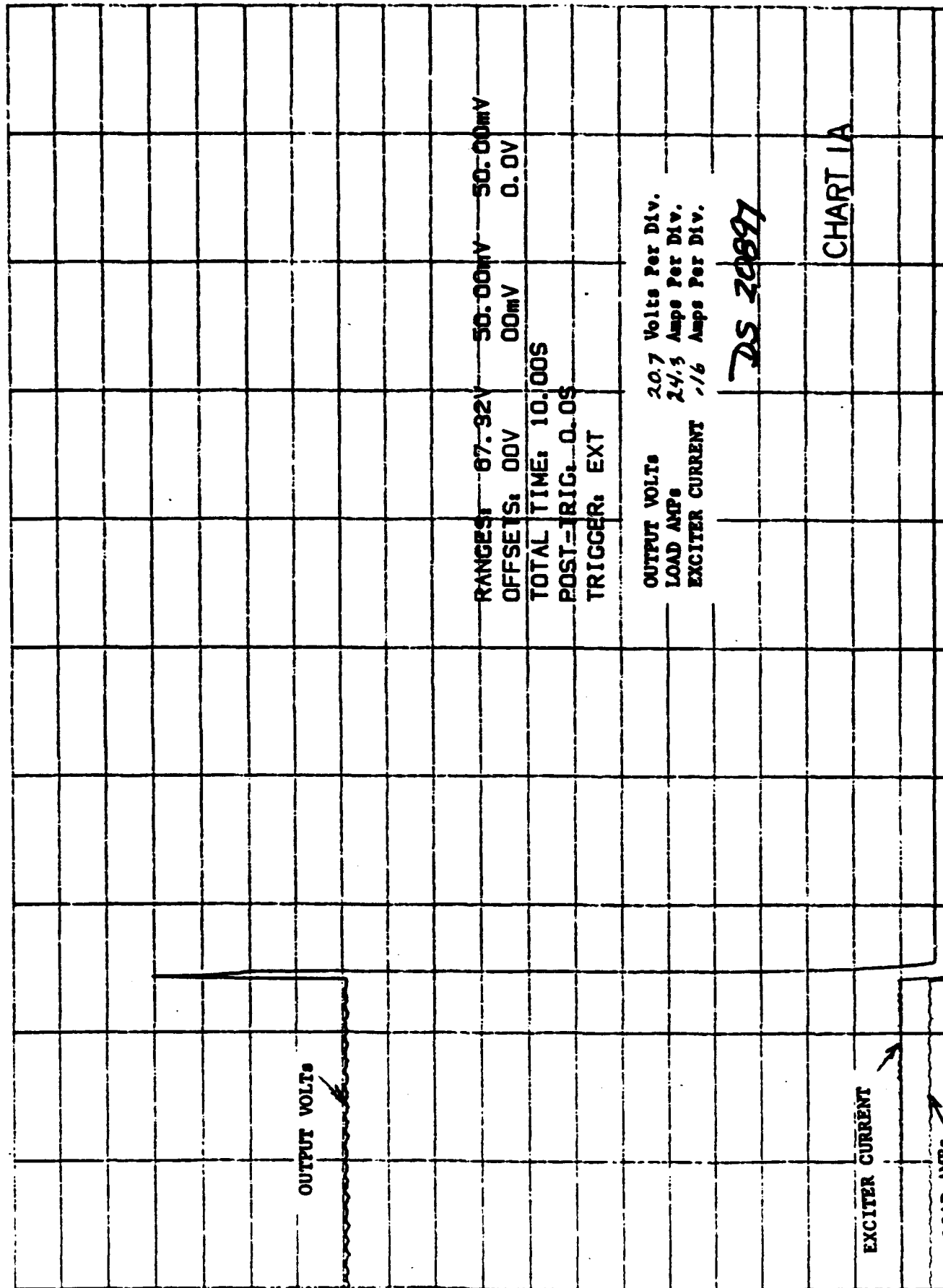
OUTPUT VOLTS 20.13 Volts Per Div.
LOAD AMPS 24.3 Amps Per Div.
EXCITER CURRENT .16 Amps Per Div.

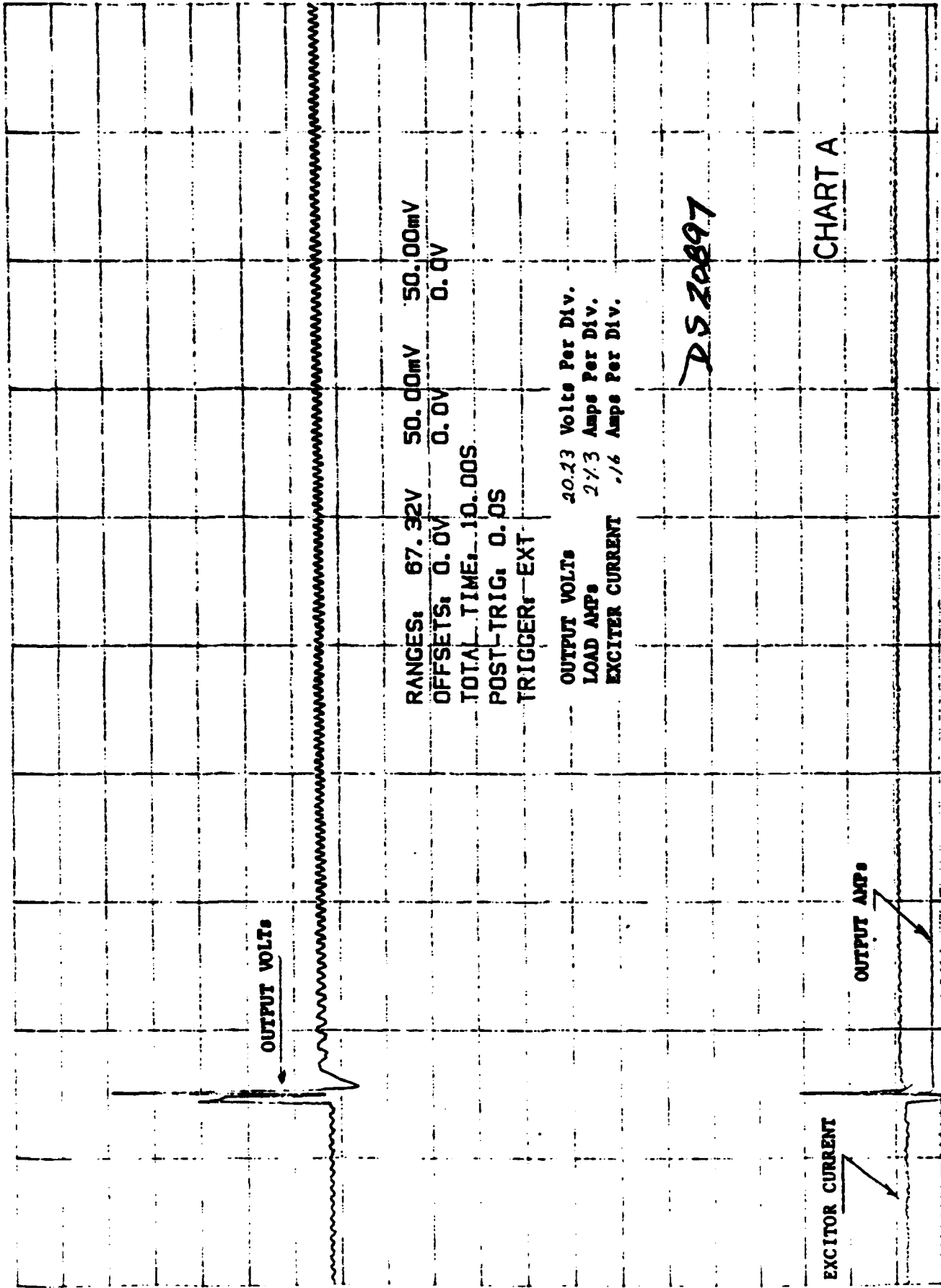
DS 20897

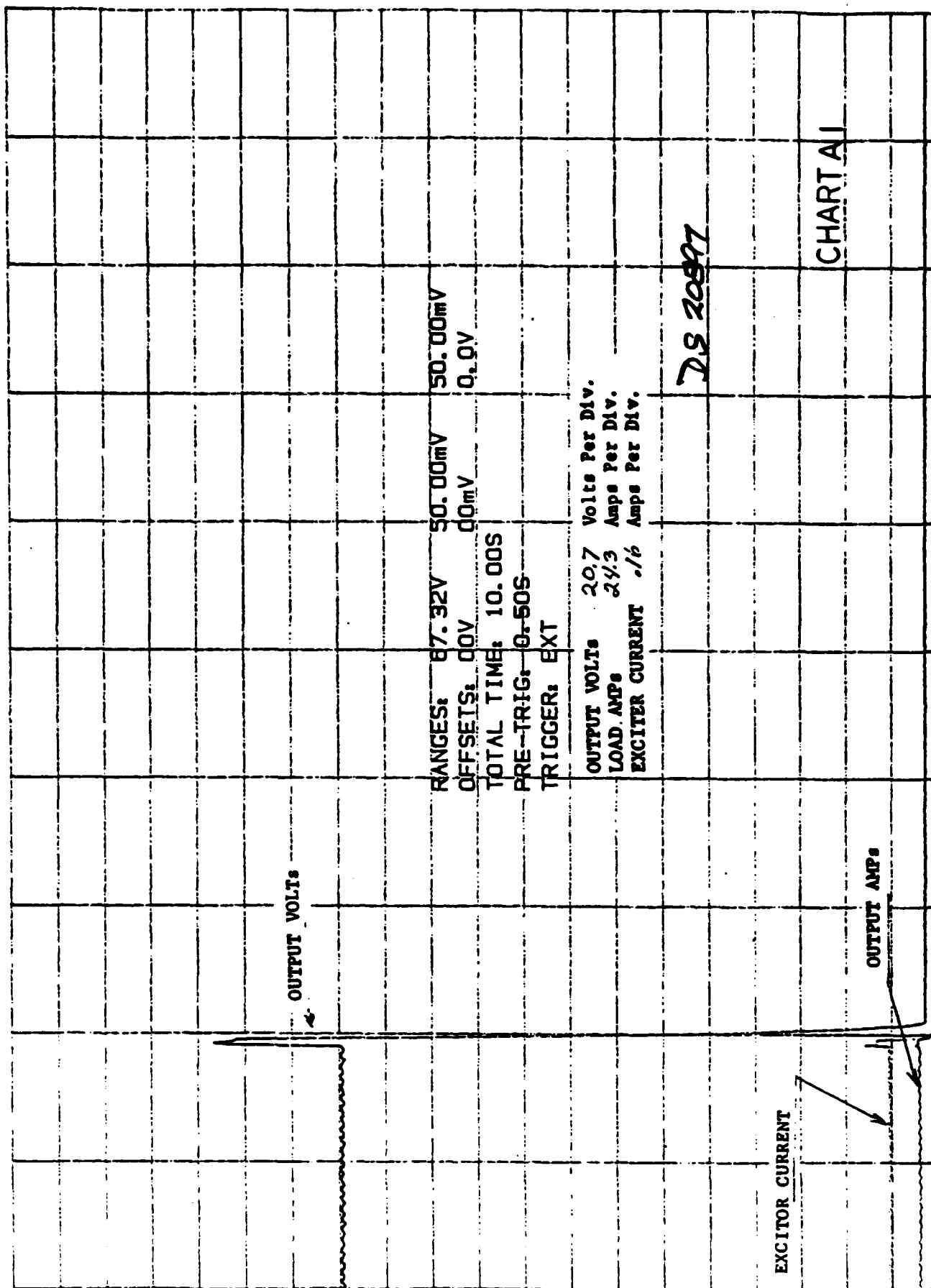
EXCITER CURRENT

LOAD AMPS

CHART 1







RANGES: 87.32V 50.00mV 50.00mV
OFFSETS: 00V 00mV 0.0V

TOTAL TIME: 10.00S
PRE-TRIG: 0.50S
TRIGGER: EXT

OUTPUT VOLTS 20.7 Volts Per Div.
LOAD AMPs 24.3 Amps Per Div.
EXCITER CURRENT 1.6 Amps Per Div.

DS 20877

CHART A1

EXCITOR CURRENT

OUTPUT AMPs

OUTPUT VOLTS

EXCITER CURRENT

LOAD AMPS

RANGES: 67.32V 50.00mV 50.00mV
OFFSETS: 0.0V 0:0V 0:0V
TOTAL TIME: 10.00S
POST-TRIG: 0.0S
TRIGGER: EXT

OUTPUT VOLTS 20.23 Volts Per Div.
LOAD AMPS 24.3 Amps Per Div.
EXCITER CURRENT .16 Amps Per Div.

DS 20097

CHART 1B

OUTPUT VOLTS

RANGES: 67.32V 50.00mV 50.00mV
OFFSETS: 00V 00mV 0.0V
TOTAL TIME: 10.00S
POST-TRIG: 0.0S
TRIGGER: EX

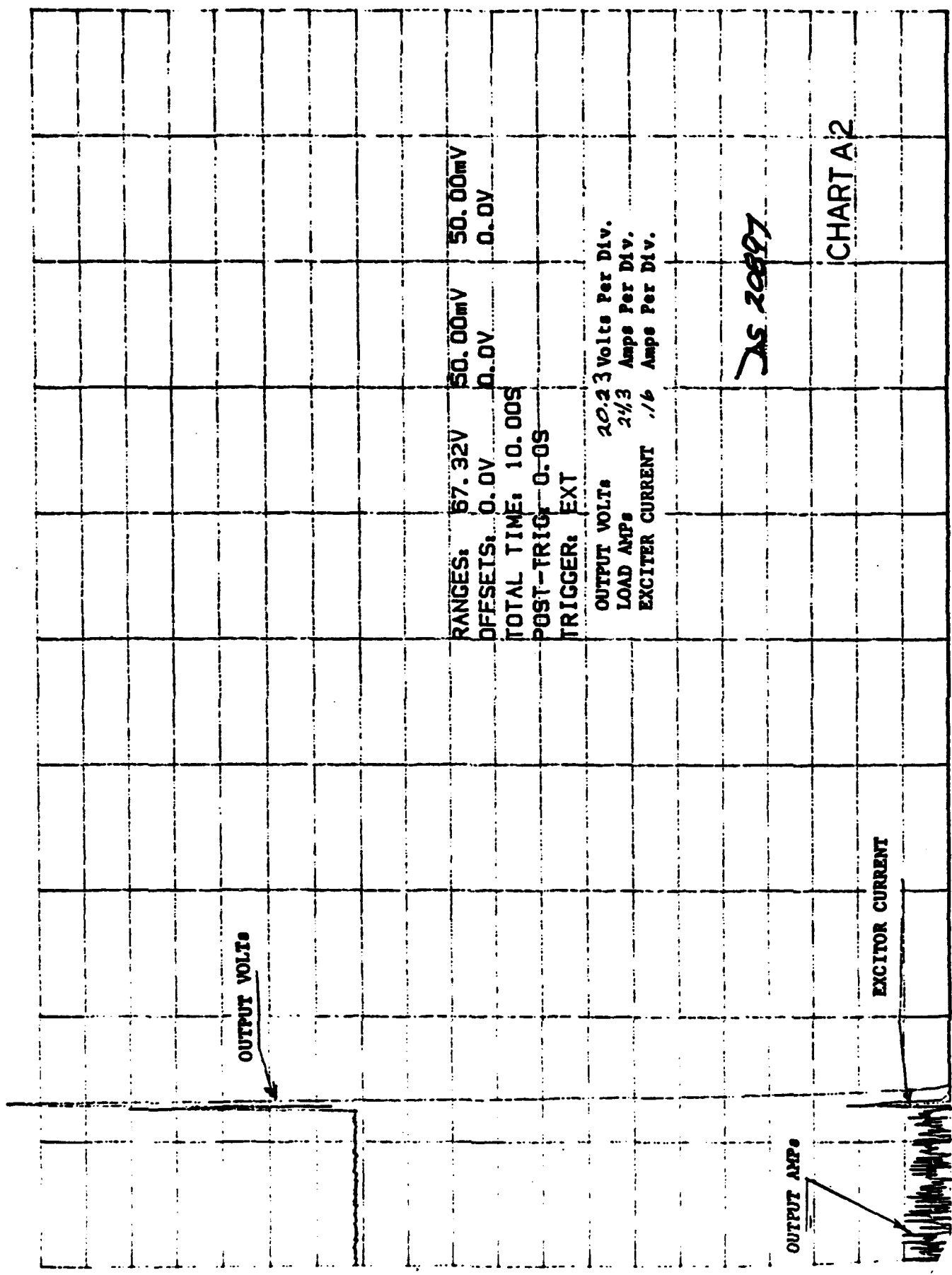
OUTPUT VOLTS 20.7 Volts Per Div.
LOAD AMPs 24.3 Amps Per Div.
EXCITER CURRENT .16 Amps Per Div.

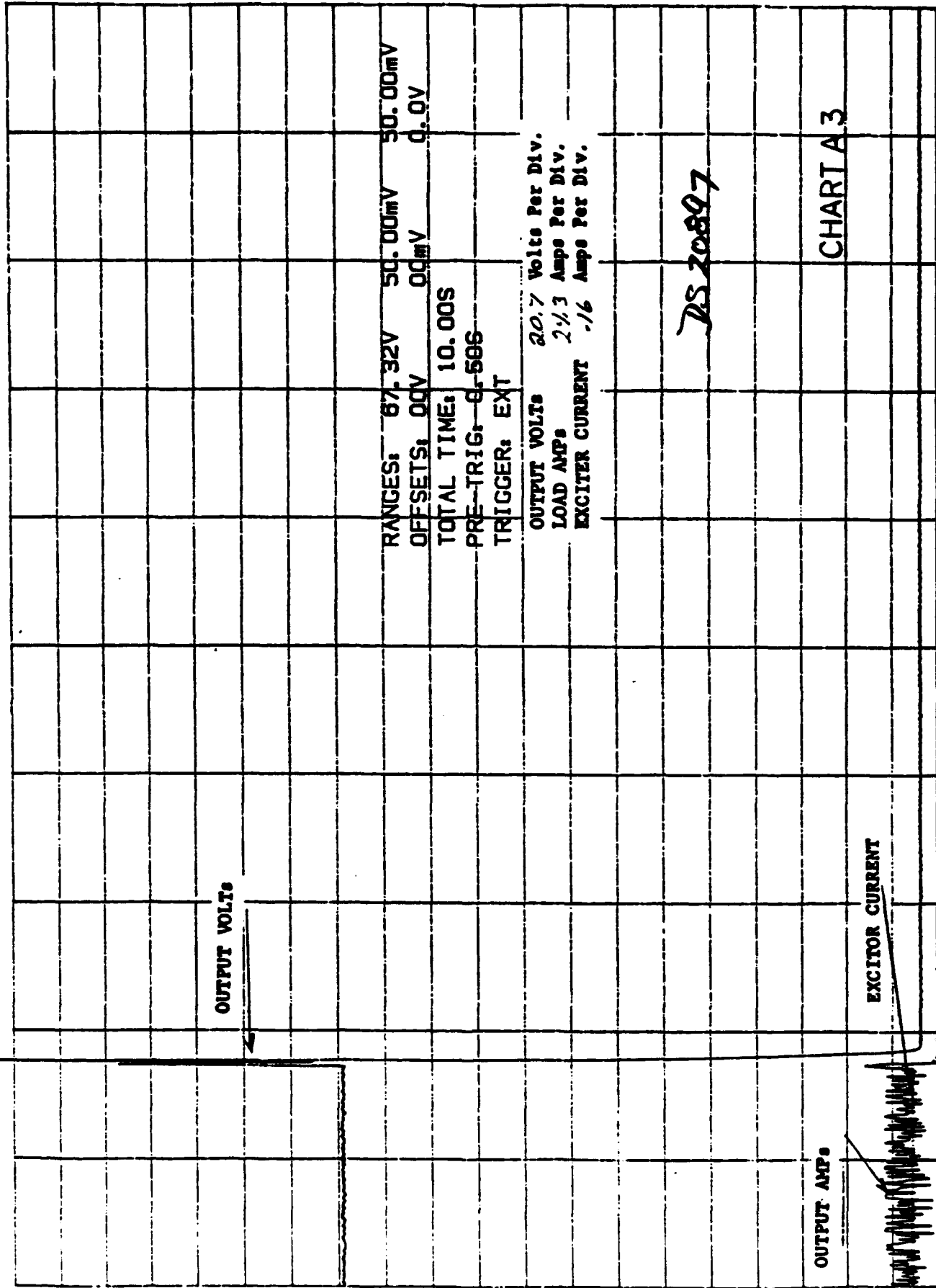
EXCITER CURRENT

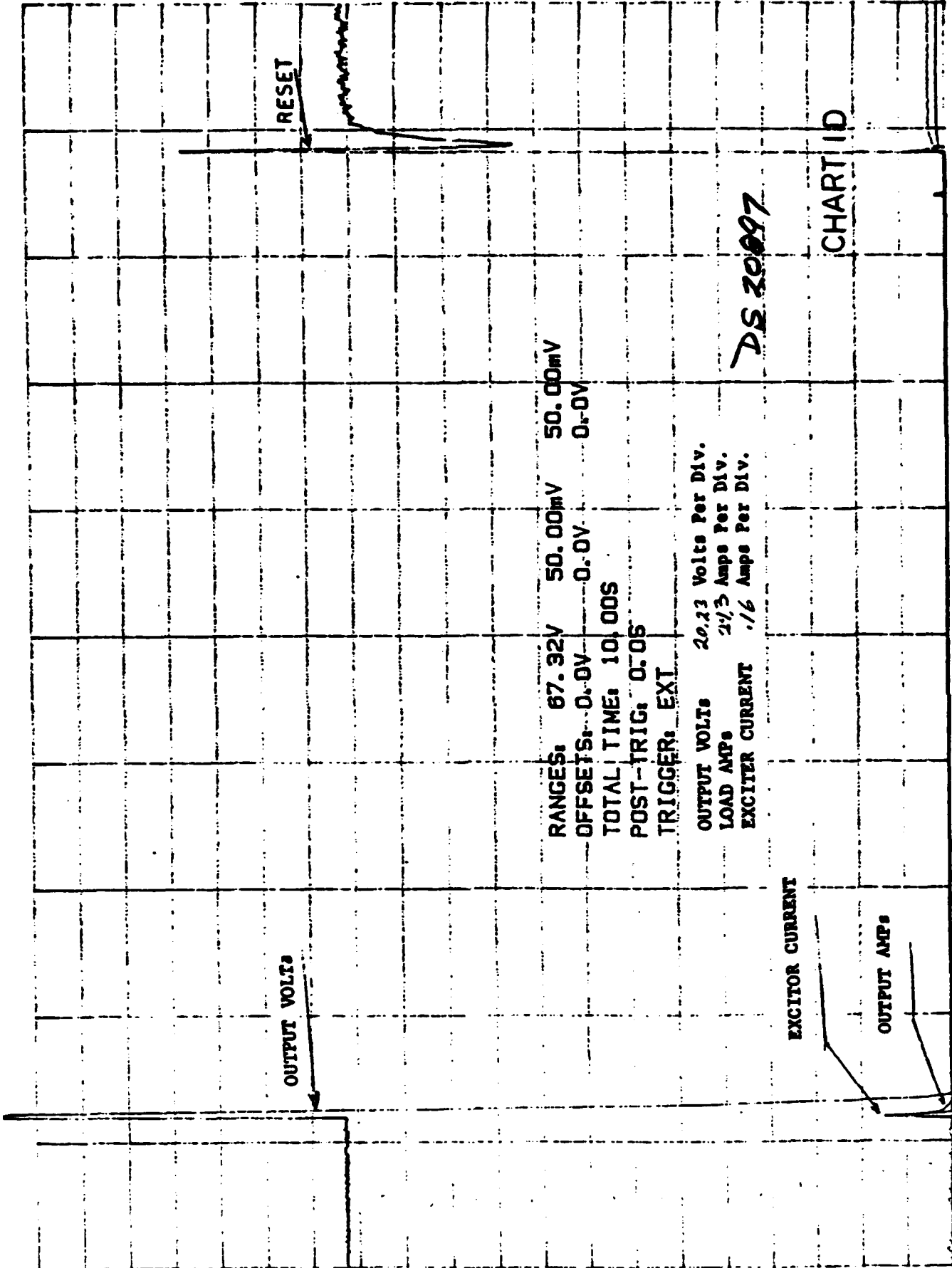
OUTPUT AMPs

DS 20097

CHART 10







RANGES: 67.32V 50.00mV 50.00mV
OFFSETS: 0.0V 0.0V 0.0V
TOTAL TIME: 10.00S
POST-TRIG: 0.05
TRIGGER: EXT

OUTPUT VOLTS 20.23 Volts Per Div.
LOAD AMPS 2/3 Amps Per Div.
EXCITER CURRENT .16 Amps Per Div.

DS 20097

CHART 10

OUTPUT VOLTS

RANGES: 67.32V 50.00mV 50.00mV

OFFSETS: 00V 00mV 0.0V

TOTAL TIME: 10.00S

POST-TRIG: 0.0S

TRIGGER: EXT

OUTPUT VOLTS 20.7 Volts Per Div.

LOAD AMPS 2.43 Amps Per Div.

EXCITOR CURRENT .16 Amps Per Div.

DS 20097

EXCITOR CURRENT

OUTPUT AMPS

CHART 1E

OUTPUT VOLTS

Handwritten scribble

OUTPUT AMPS

EXCITOR CURRENT

RANGES: 67.32V 50.00mV 50.00mV
OFFSETS: 0.0V 0.0V 0.0V
TOTAL TIME: 10.00S
POST-TRIG: 0.0S
TRIGGER: EXT

OUTPUT VOLTS 20.23 Volts Per Div.
LOAD AMPS 24.3 Amps Per Div.
EXCITER CURRENT .16 Amps Per Div.

DS20897

CHART A4



OUTPUT VOLTS

[Handwritten scribbles]

RANGES: 67.32V 50.00mV 50.00mV
OFFSETS: 00V 00mV 0.0V

TOTAL TIME: 10.00S

PRE-TRIG: 0.50S

TRIGGER: EXT

OUTPUT VOLTS 20.7 Volts Per Div.
LOAD AMPS 21.3 Amps Per Div.
EXCITER CURRENT .16 Amps Per Div.

DS 20897

OUTPUT AMPs

EXCITER CURRENT

[Handwritten scribbles]

CHART A5

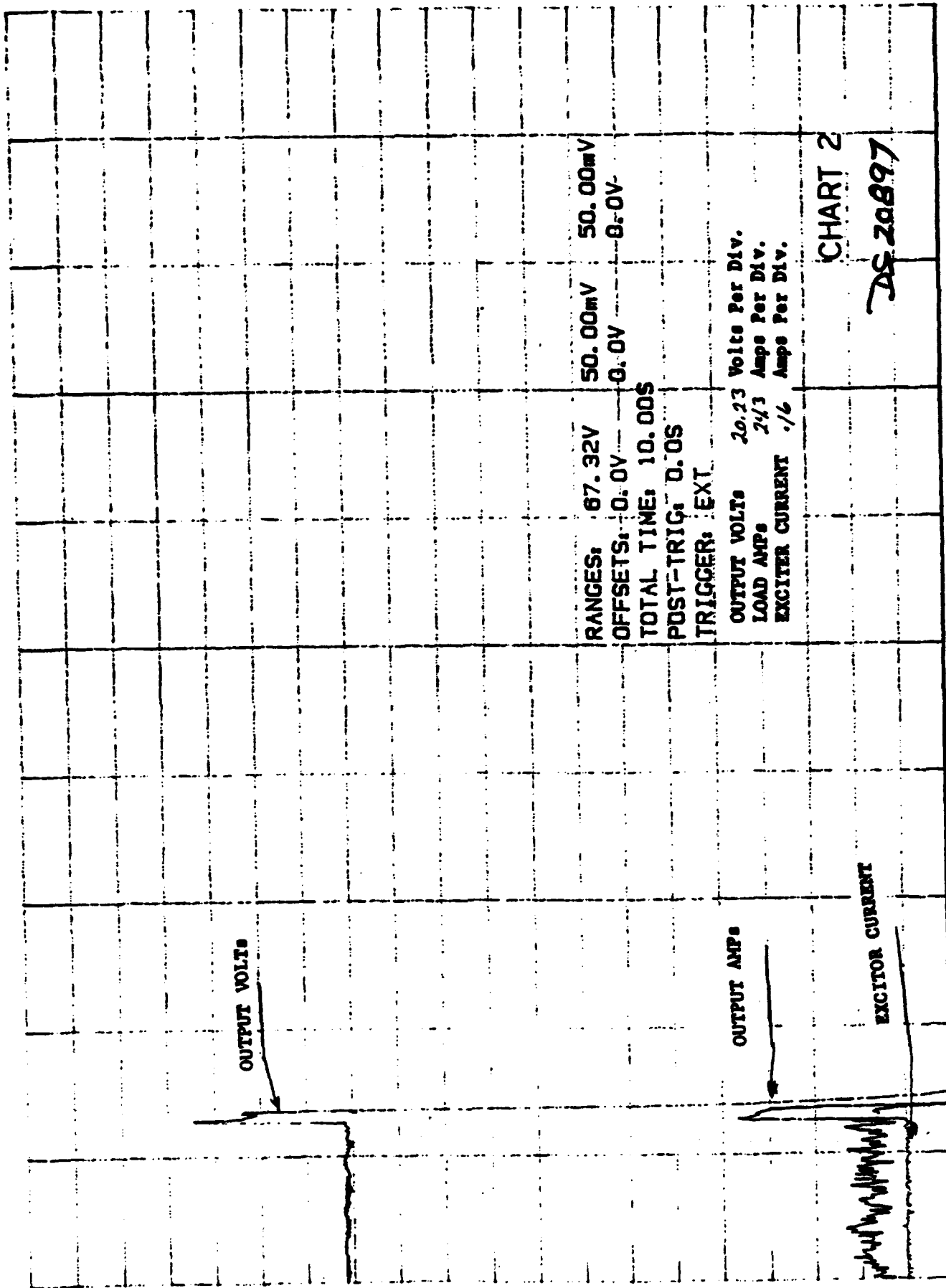
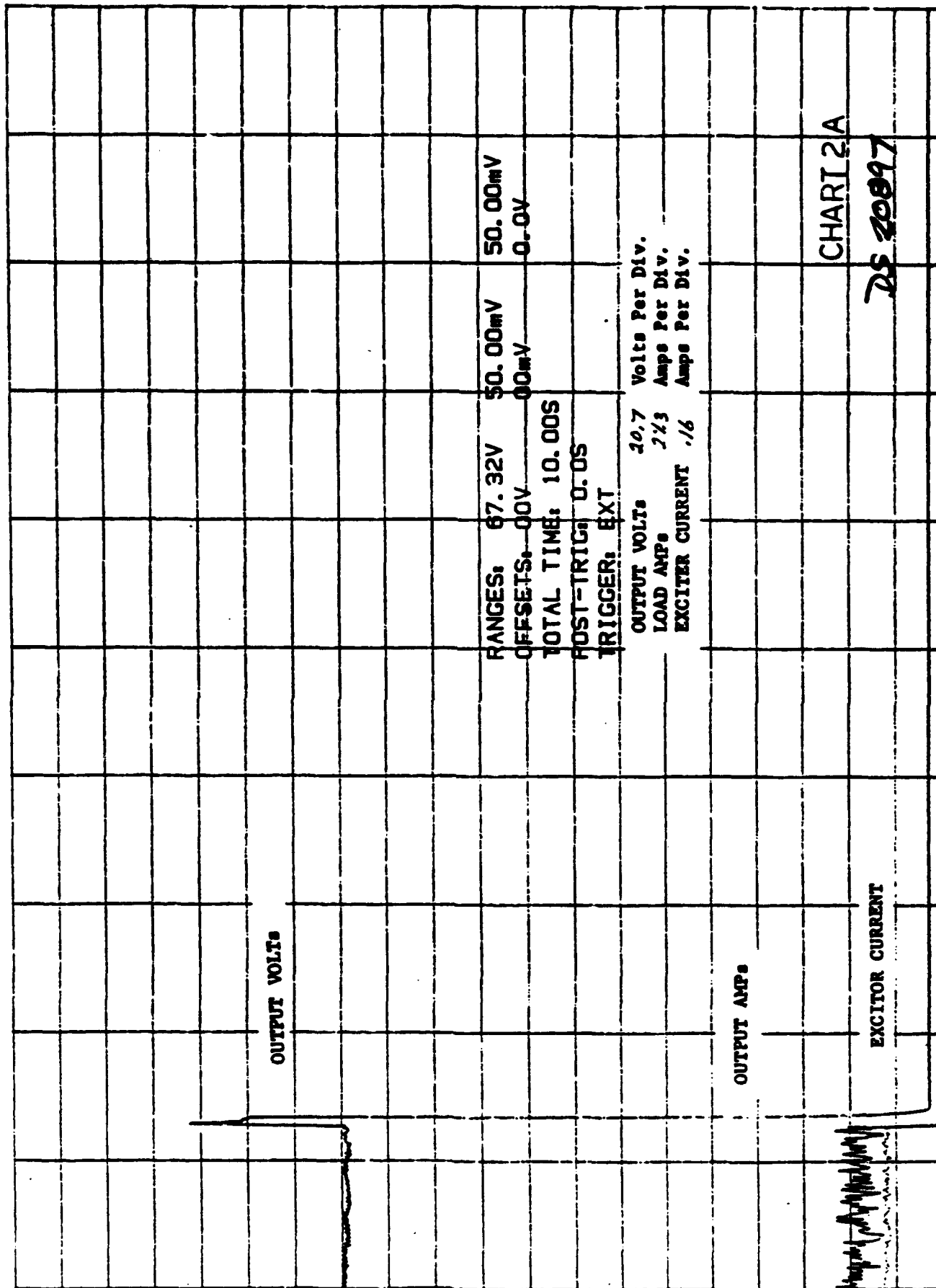


CHART 2

DS 20897



OUTPUT VOLTS

RANGES: 67.32V 50.00mV 50.00mV
OFFSETS: 0.0V 0.0V 0.0V
TOTAL TIME: 10.00S
POST-TRIG: 0.0S
TRIGGER: EXT

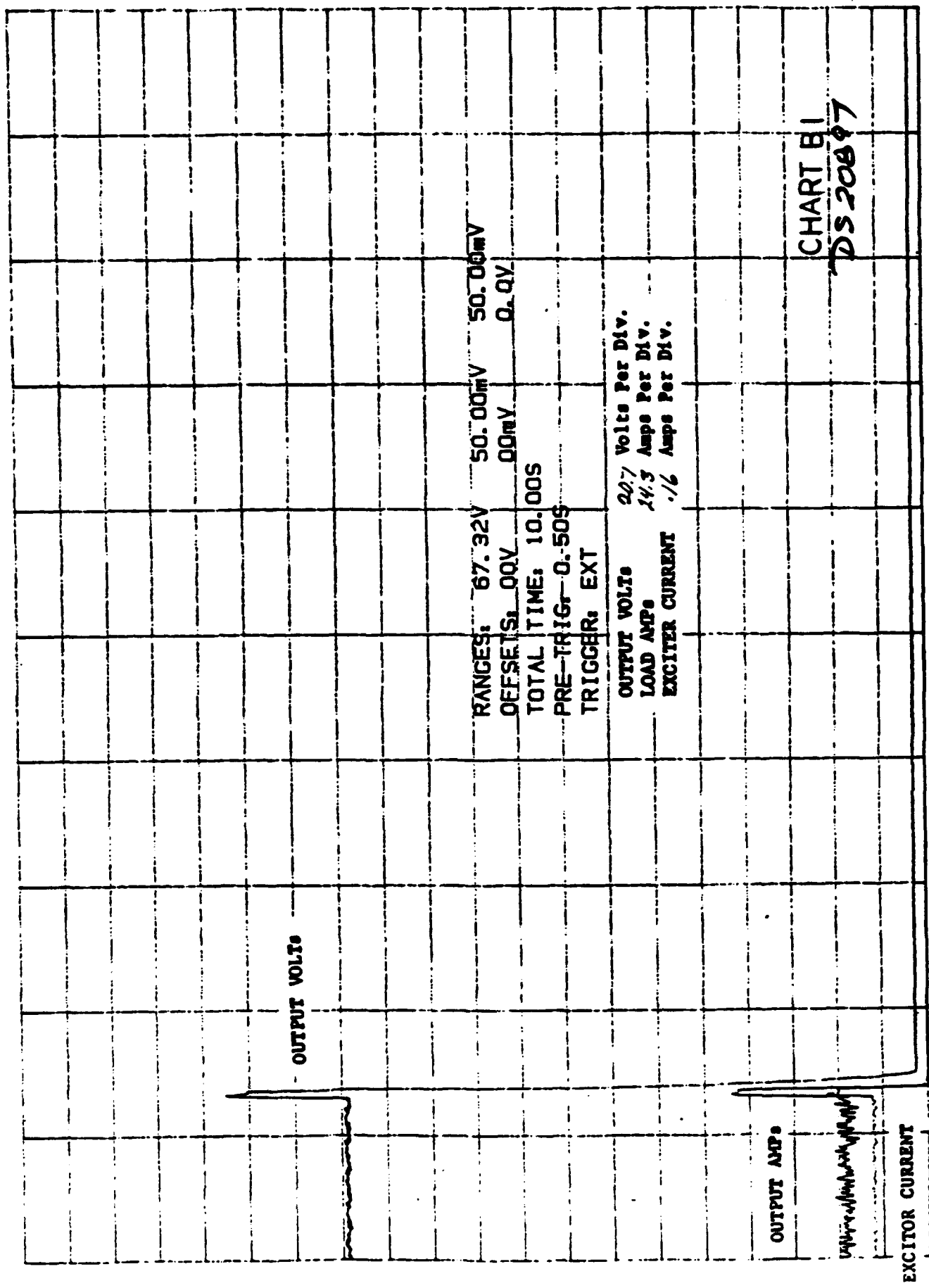
OUTPUT VOLTS 20.23 Volts Per Div.
LOAD AMPs 24.3 Amps Per Div.
EXCITER CURRENT 1.6 Amps Per Div.

OUTPUT AMPs

EXCITER CURRENT

CHART B

2820897



OUTPUT VOLTS

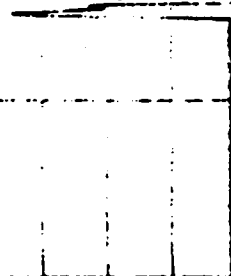
OUTPUT AMP

EXCITOR CURRENT

RANGES: 67.32V 50.00mV 50.00mV
OFFSETS: 00V 00mV 0.0V
TOTAL TIME: 10.00S
PRE-TRIG: 0.50S
TRIGGER: EXT
OUTPUT VOLTS 20.7 Volts Per Div.
LOAD AMP 14.3 Amps Per Div.
EXCITER CURRENT .16 Amps Per Div.

CHART B1
DS 20897

OUTPUT VOLTS



RANGES: 67.32V 50.00mV 50.00mV
OFFSETS: 0.0V 0.0V 0.0V
TOTAL TIME: 10.00S
POST-TRIG: 0.0S
TRIGGER: EXT

OUTPUT VOLTS 20.23 Volts Per Div.
LOAD AMPS 2.13 Amps Per Div.
EXCITER CURRENT 1/6 Amps Per Div.

OUTPUT AMPS

EXCITOR CURRENT

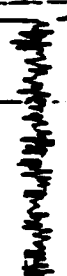
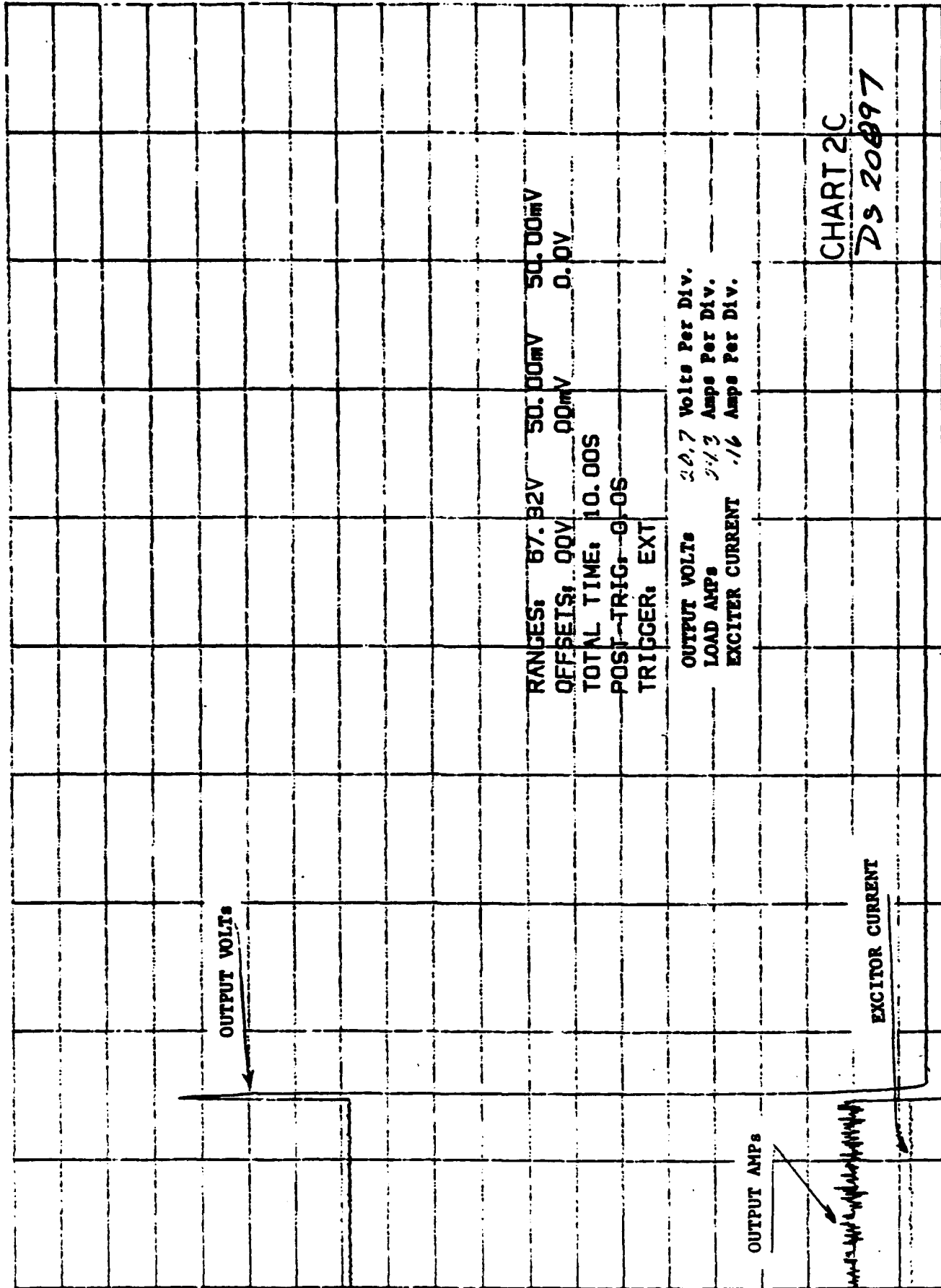


CHART 2B

DS 20097



OUTPUT VOLTS

OUTPUT AMPS

EXCITOR CURRENT

RANGES: 67.32V 50.00mV 50.00mV

OFFSETS: 0.0V 0.0V 0.0V

TOTAL TIME: 10.00S

POST-TRIG: 0.0S

TRIGGER: EXT

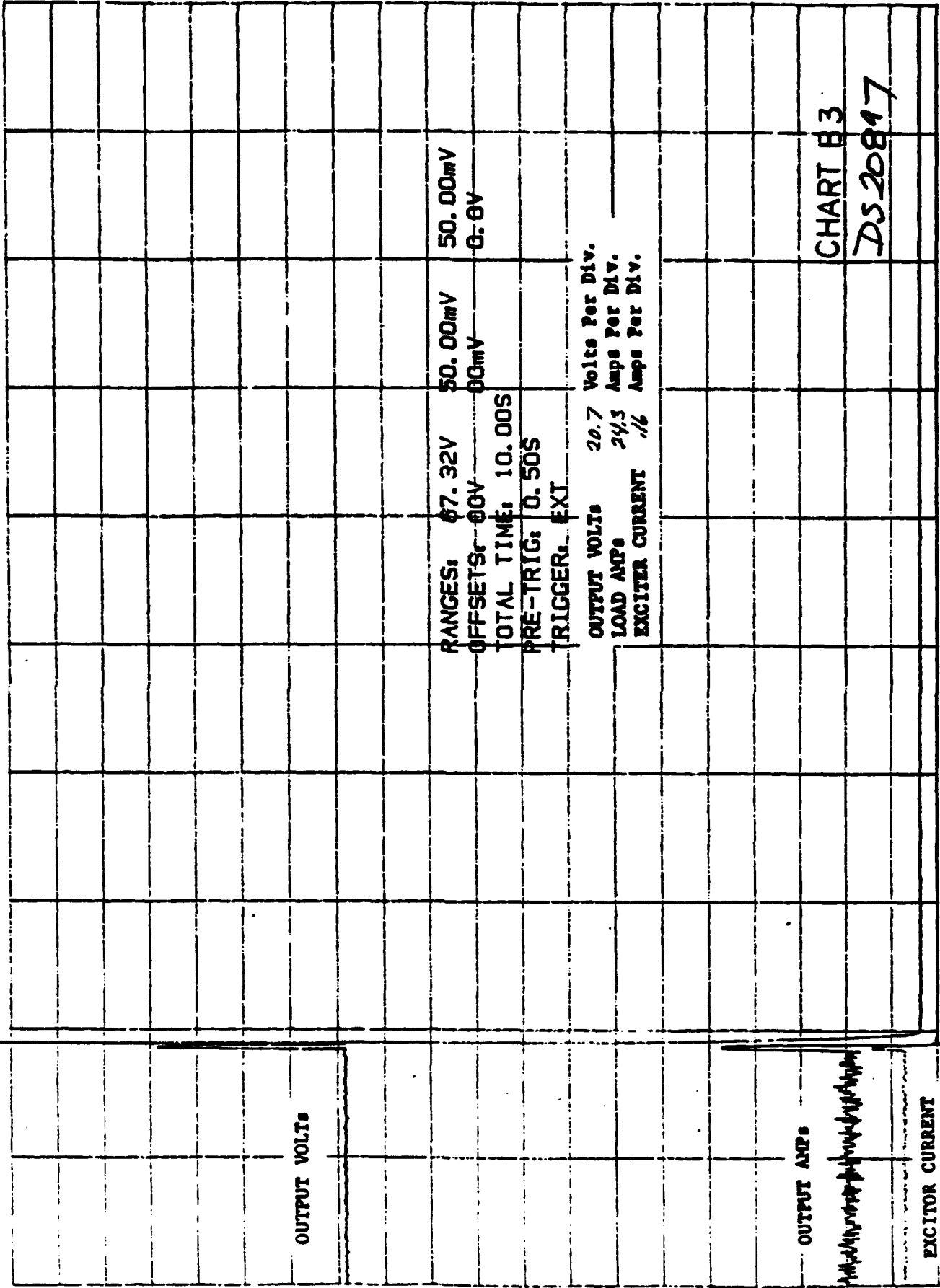
OUTPUT VOLTS 20.23 Volts Per Div.

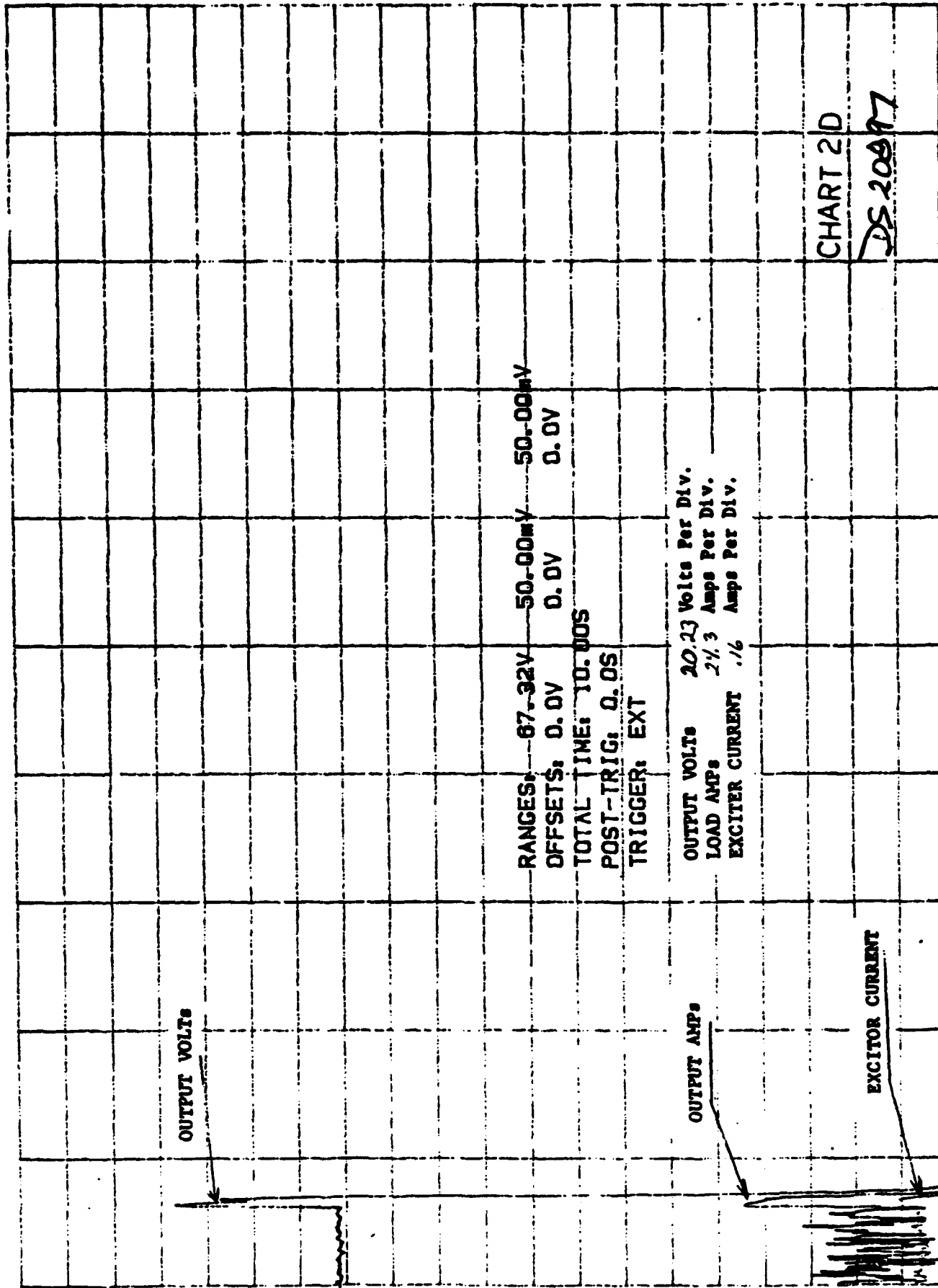
LOAD AMPS 2.13 Amps Per Div.

EXCITER CURRENT .16 Amps Per Div.

CHART B 2

2520897





OUTPUT VOLTS

OUTPUT AMPs

EXCITOR CURRENT

RANGES: 67.92V 50.00mV 50.00mV
OFFSETS: 00V 00mV 0.0V
TOTAL TIME: 10.00S
POST-TRIG: 0.0S
TRIGGER: EXT

OUTPUT VOLTS 20.7 Volts Per Div.
LOAD AMPs 14.3 Amps Per Div.
EXCITER CURRENT .16 Amps Per Div.

CHART 2E

DS 20897

OUTPUT VOLTS

OUTPUT AMPs

EXCITOR CURRENT

RANGES: 87.32V 50.00mV 50.00mV
OFFSETS: 0.0V 0.0V 0.0V
TOTAL TIME: 10.00S
POST-TRIG: 0.0S
TRIGGER: EXT

OUTPUT VOLTS 20.23 Volts Per Div.
LOAD AMPs 2.43 Amps Per Div.
EXCITOR CURRENT .16 Amps Per Div.

CHART B4

DS 20897

OUTPUT VOLTS

OUTPUT AMPS

EXCITOR CURRENT

RANGES: 67.32V 50.00mV 50.00mV

OFFSETS: 00V 00mV 0.0V

TOTAL TIME: 10.00S

PRE-TRIG: 0.50S

TRIGGER: EXT

OUTPUT VOLTS 20.7 Volts Per Div.

LOAD AMPS 24/3 Amps Per Div.

EXCITER CURRENT 1/6 Amps Per Div.

CHART B5

DS 20097

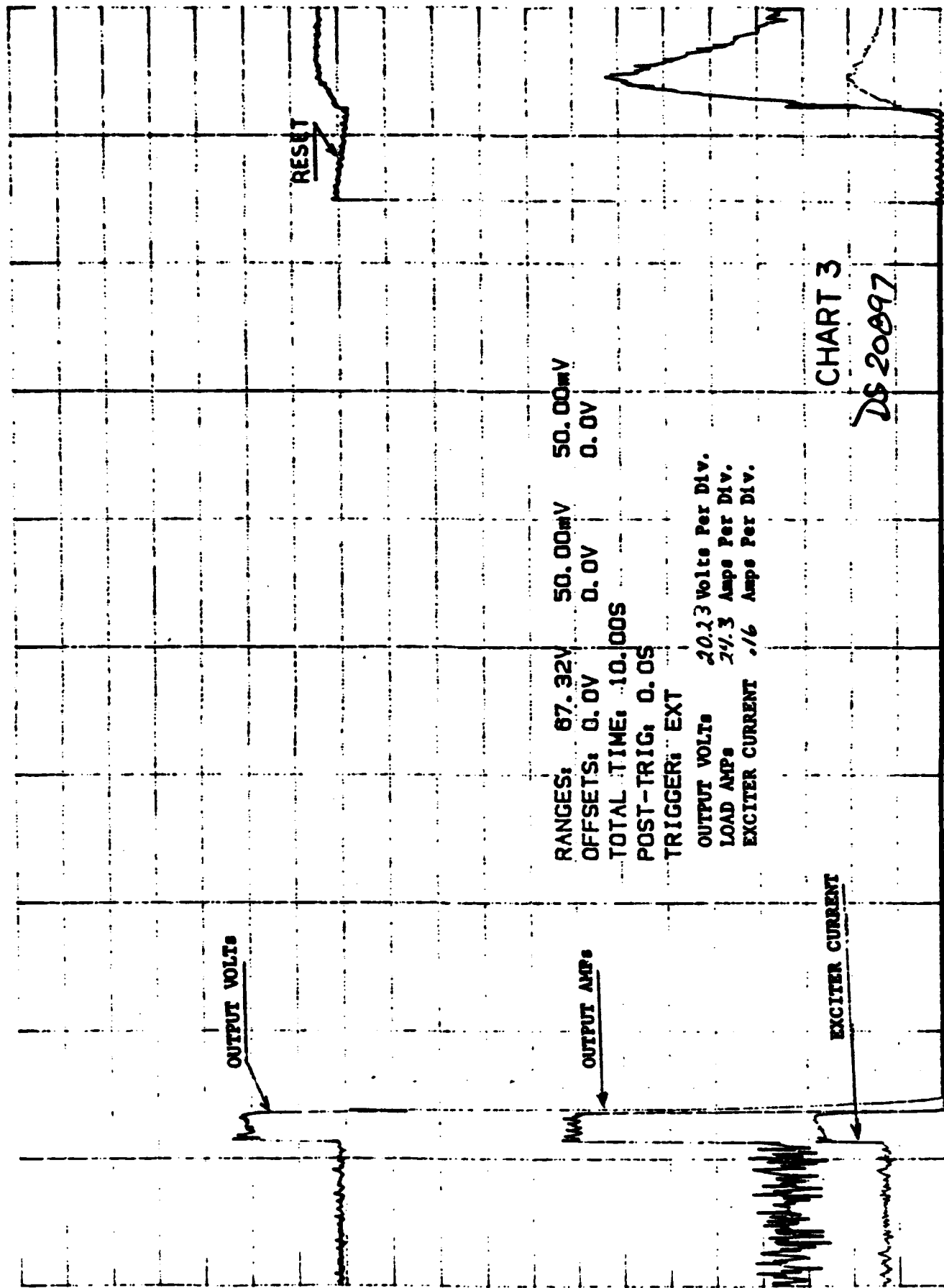
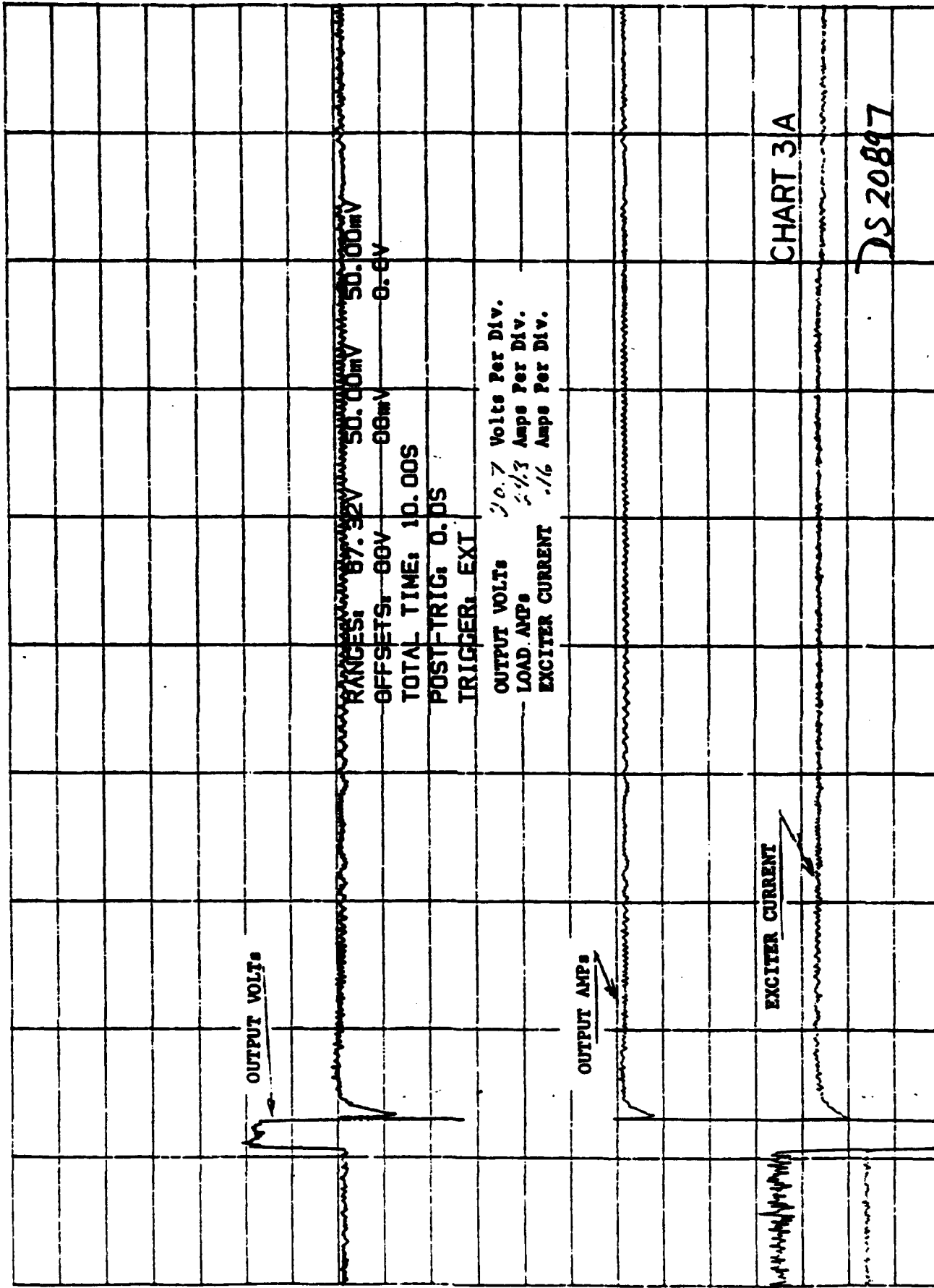


CHART 3

DS 20097



OUTPUT VOLTS

RANGES: 67.32V 50.00mV 50.00mV

OFFSETS: 0.0V 0.0V 0.0V

TOTAL TIME: 10.00S

POST-TRIG: 0.0S

TRIGGER: EXT

OUTPUT VOLTS 20.23 Volts Per Div.

LOAD AMPS 2.13 Amps Per Div.

EXCITER CURRENT .16 Amps Per Div.

OUTPUT AMPS

EXCITER CURRENT

CHART C

PS 20897

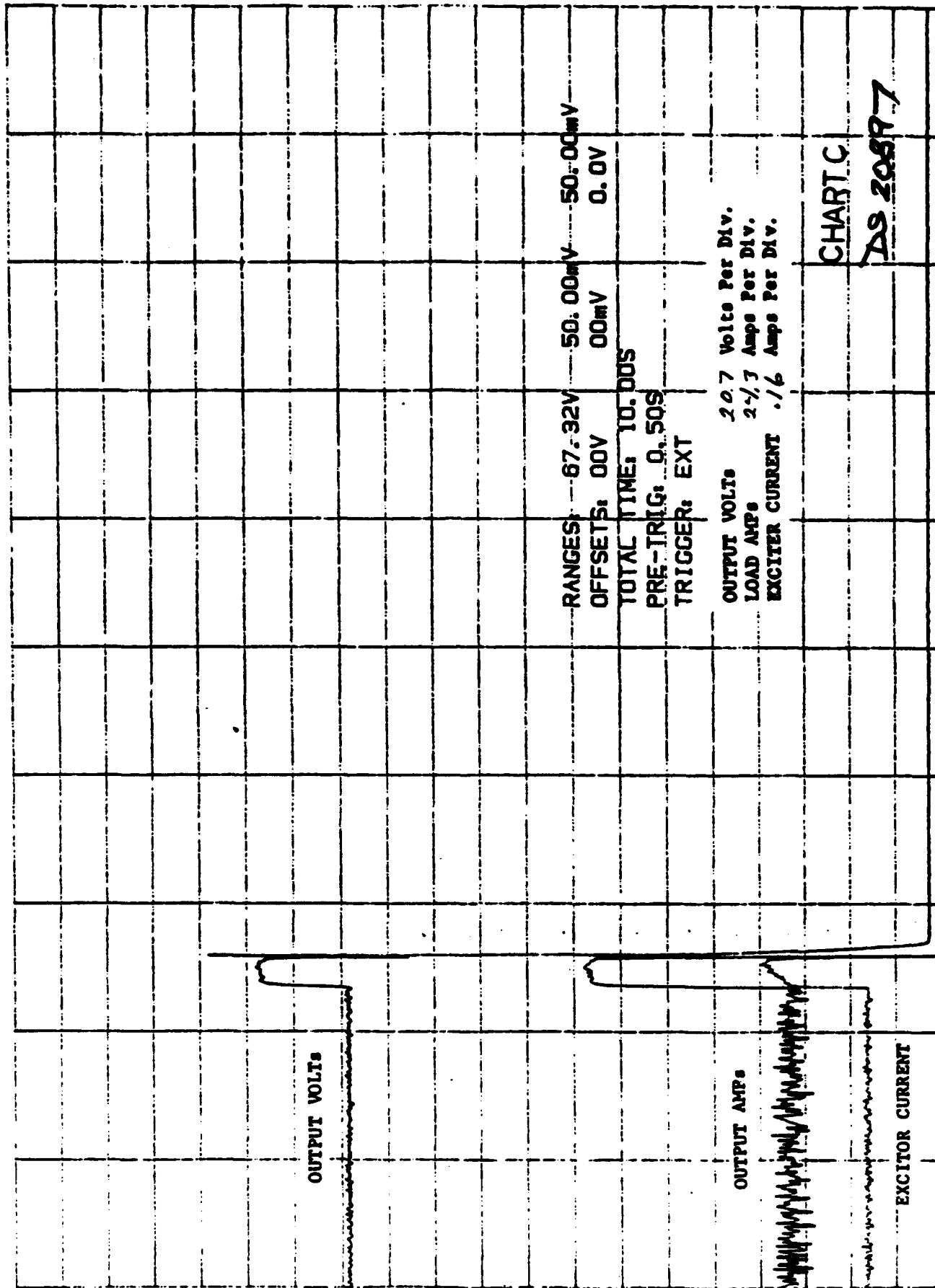
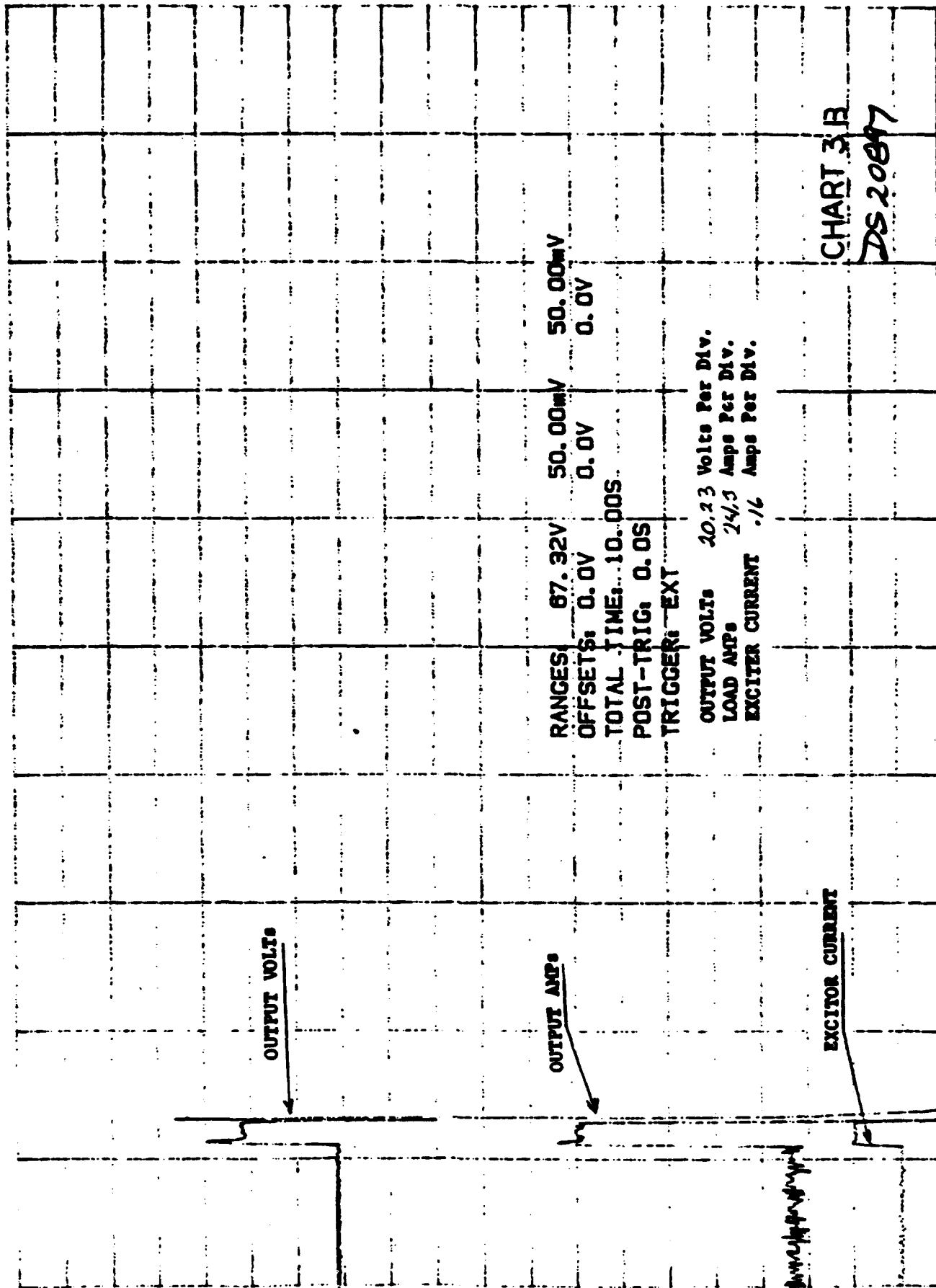
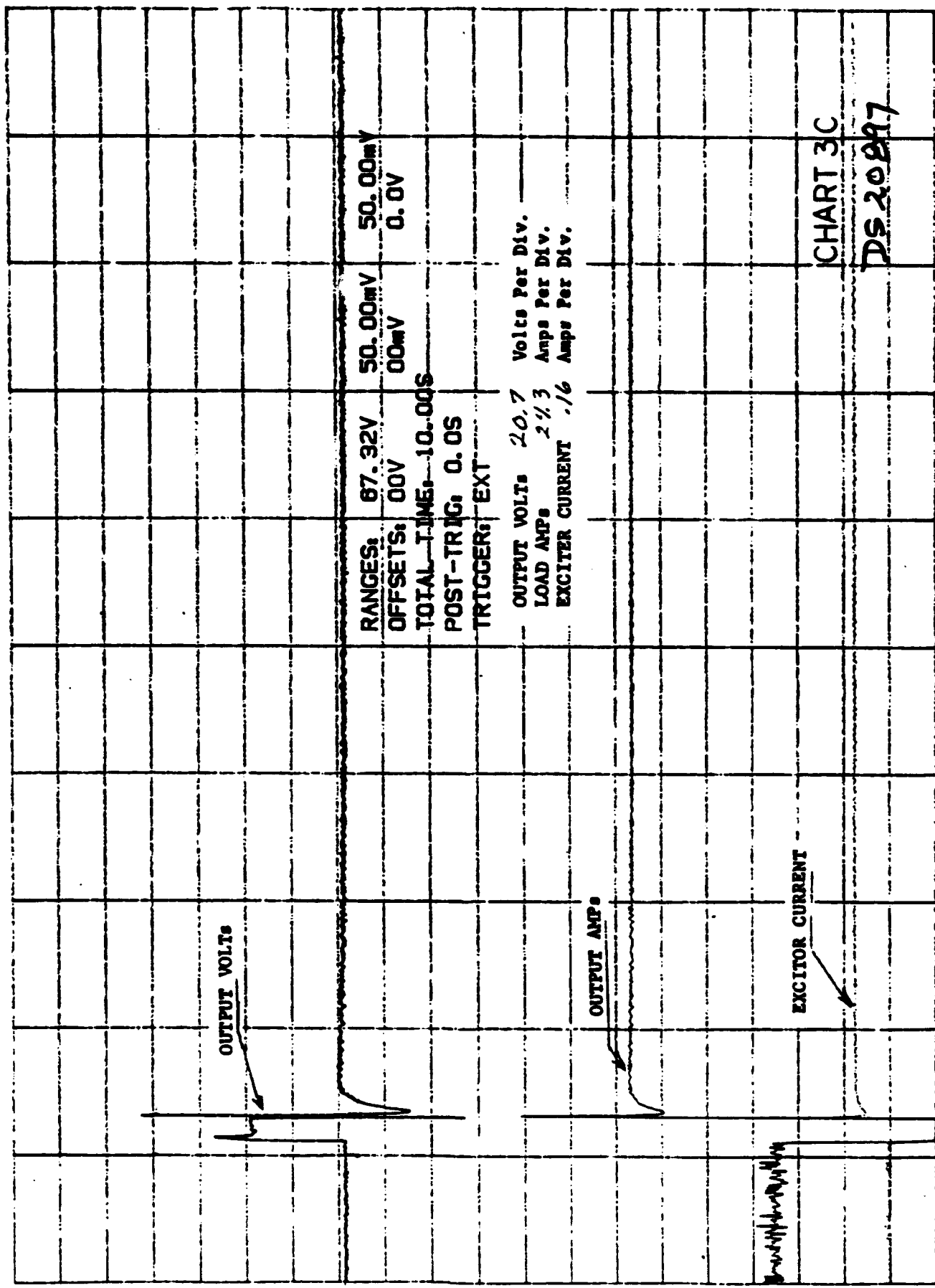


CHART C

DS 20897





RANGES: 87.32V 50.00mV 50.00mV
OFFSETS: 00V 00mV 0.0V
TOTAL TIME: 10.00S
POST-TRIG: 0.0S
TRIGGER: EXT

OUTPUT VOLTS 20.7 Volts Per Div.
LOAD AMPs 21.3 Amps Per Div.
EXCITER CURRENT .16 Amps Per Div.

CHART 3C
DS 20897

OUTPUT VOLTS

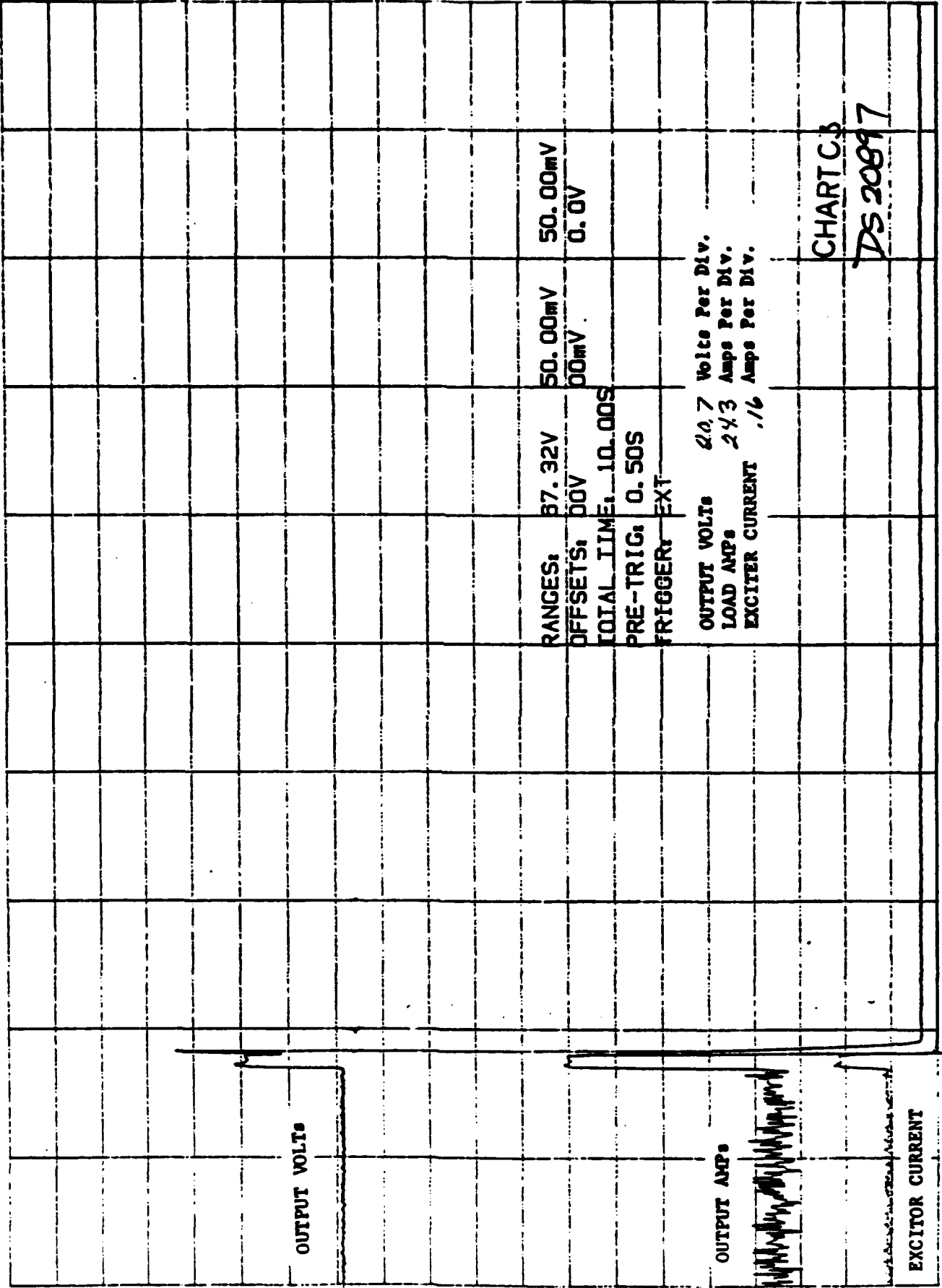
OUTPUT AMPS

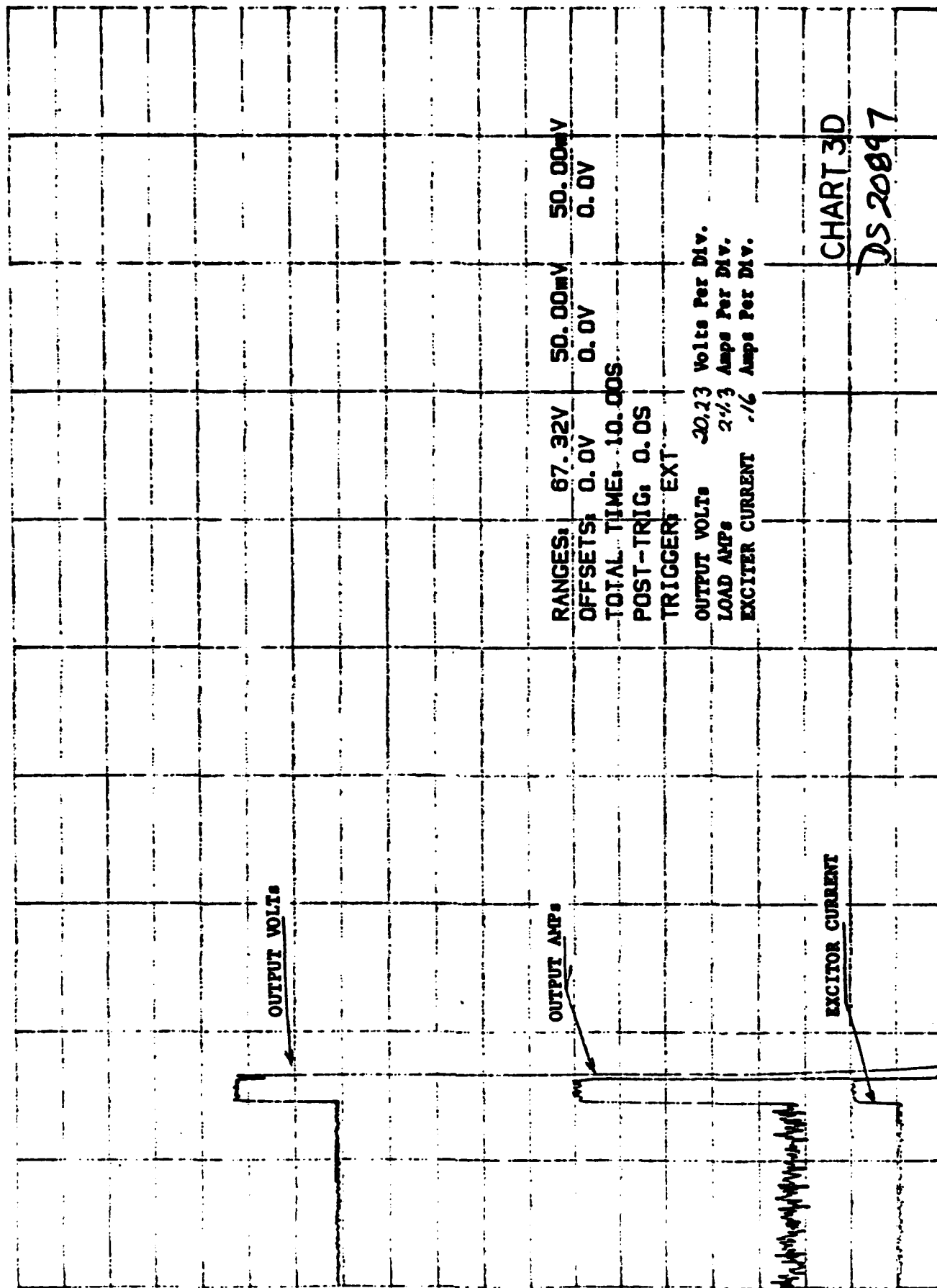
EXCITOR CURRENT

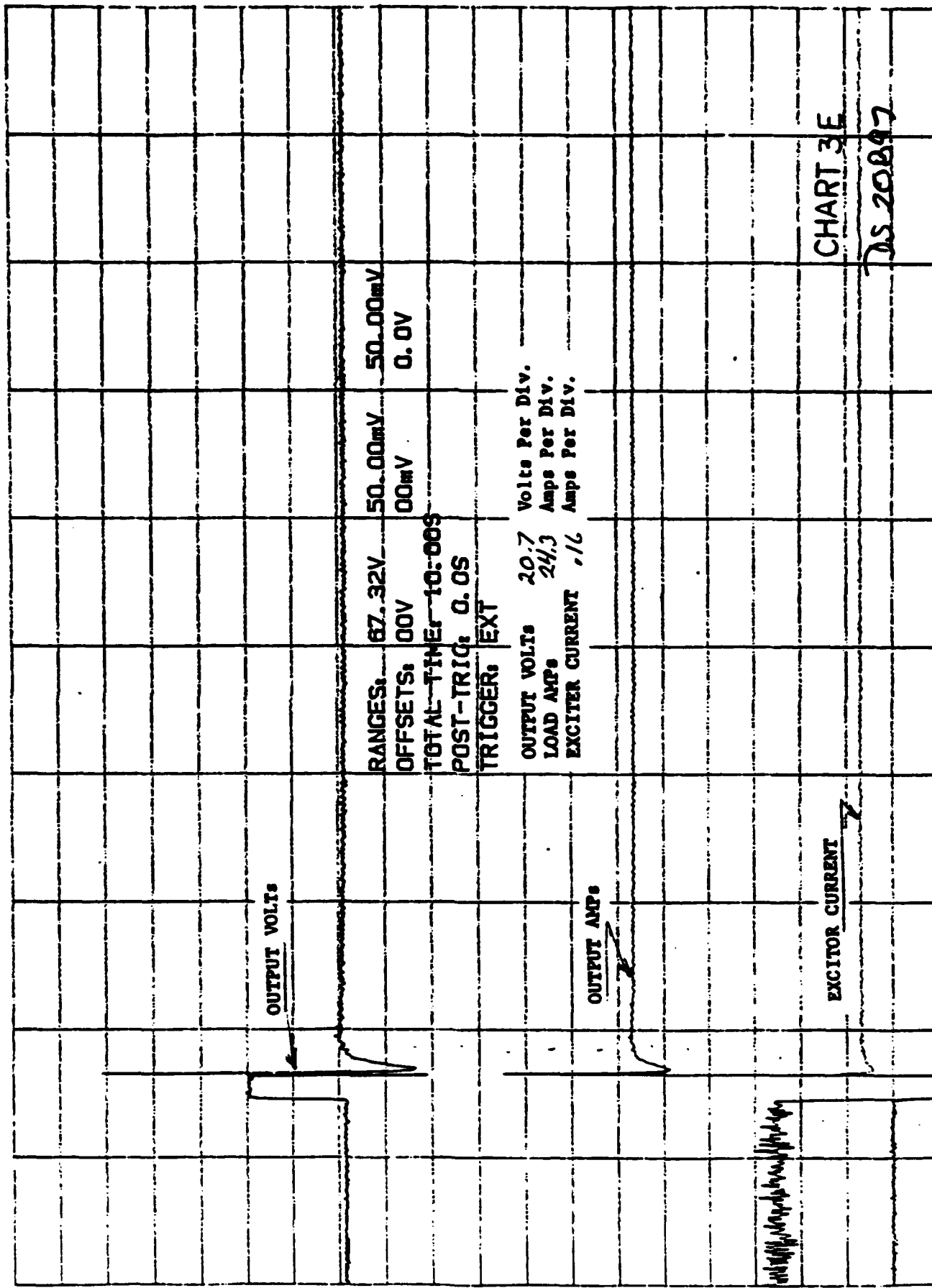
RANGES: 67.32V 50.00mV 50.00mV
OFFSETS: 0.0V 0.0V 0.0V
TOTAL TIME: 10.00S
POST-TRIG: 0.0S
TRIGGER: EXT
OUTPUT VOLTS 20.23 Volts Per Div.
LOAD AMPS 24.3 Amps Per Div.
EXCITER CURRENT 1.6 Amps Per Div.

CHART C2

DS20897







OUTPUT VOLTS

OUTPUT AMPS

EXCITOR CURRENT

RANGES: 67.32V 50.00mV 50.00mV

OFFSETS: 00V 00mV 0.0V

TOTAL TIME: 10.00S

POST-TRIG: 0.0S

TRIGGER: EXT

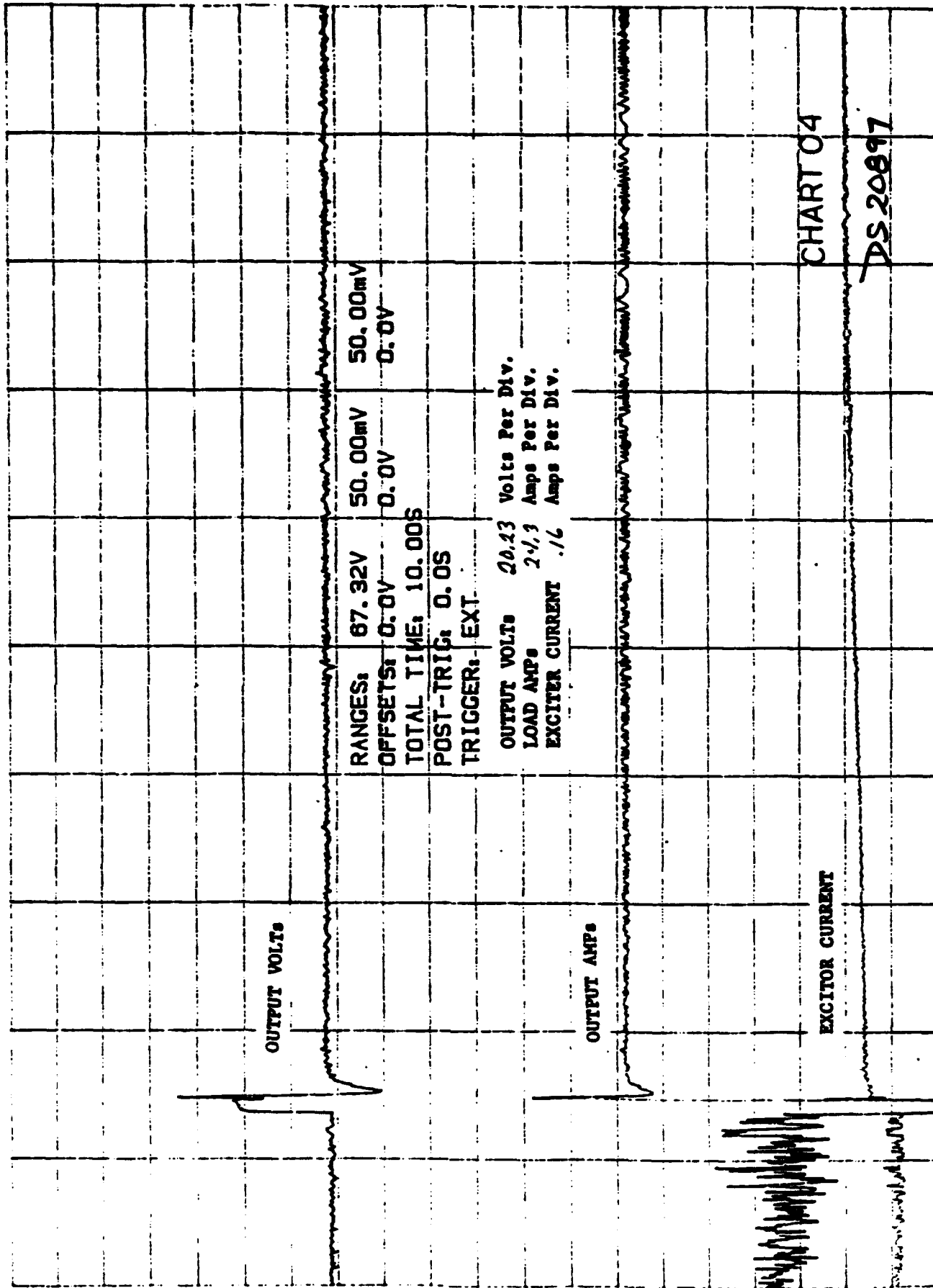
OUTPUT VOLTS 20.7 Volts Per Div.

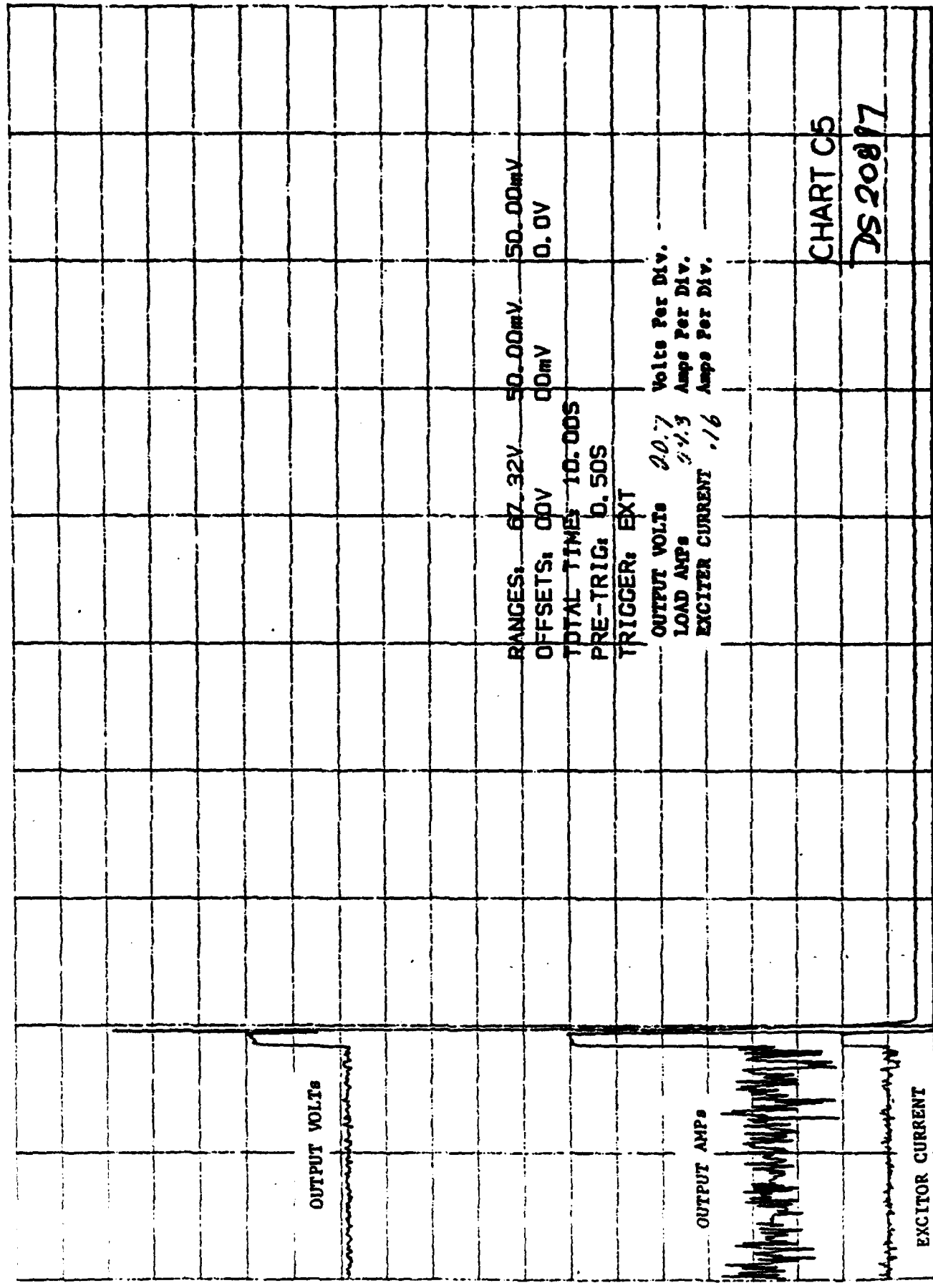
LOAD AMPS 24.3 Amps Per Div.

EXCITER CURRENT 16 Amps Per Div.

CHART 3E

DS 20897





Undervoltage Function Trip

Purpose: The purpose of this test was to demonstrate the effectiveness of system protection when a fault exists on one channel of a parallel system resulting in an underexcitation-undervoltage condition.

Procedure: Two systems, I and II, were operated in parallel at 10,000, 16,000, and 18,000 rpm. At each of these speeds, tests were run at 0, 50, and 100% rated load with faults applied first to system I and then to system II.

Results: Test results are tabulated in Table 5-5. This table corresponds to LAPEC data sheet 20898 and accompanying charts.

Discussion of Results: The operation of the parallel system during underexcitation is greatly influenced by the load (provides bias to the undervoltage detection circuit) the specific system generator carries. Therefore, when the systems are operating no load (5 amperes pre-loads not included) no or the same bias is provided for the detectors. The opening of one system exciter field (underexcitation) will not affect the bias and therefore, the sensing circuit cannot detect the underexcited condition correctly (see traces 1 thru A5). Transients created by the "chattering" of switch opening create high overvoltage conditions sometimes resulting in the loss of both systems.

Underexcitation with the two systems carrying 167 amperes (see traces 3 thru C5) is properly detected and the faulty system isolated in approximately 5 seconds. Traces, identified as half-load (83.5 amperes) tests by data sheet DS2089B, were lost, only two traces "B" and "B1" were found. These show correct operation of system II (faulted) undervoltage protection. The above test results show, that the detection of underexcitation needs to be improved to the condition of no-load (or very light load) conditions as well, by sensing the exciter field current along with the load current for the detection of underexcitation.

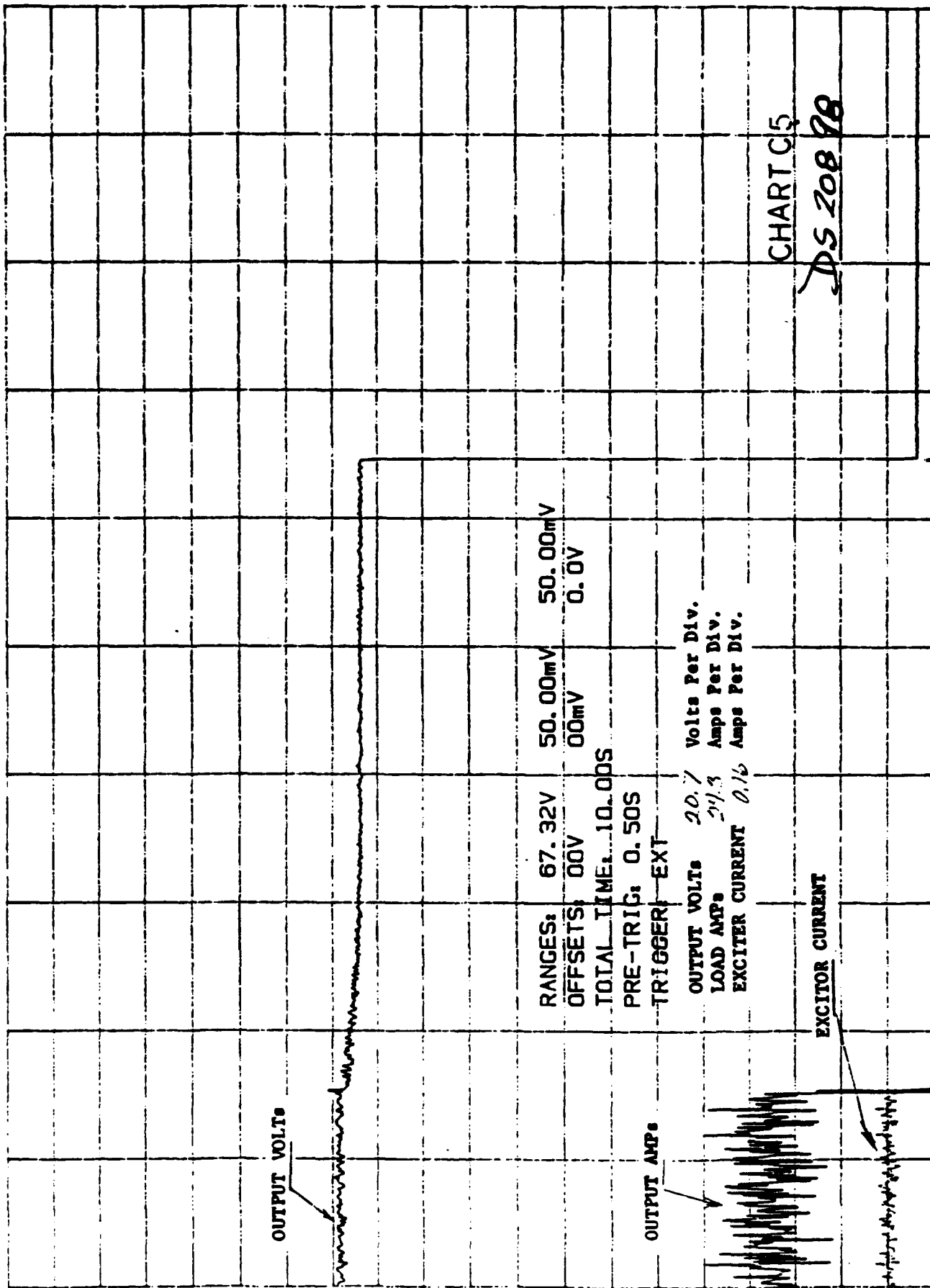


CHART C5

DS 208 78

TABLE 5-5

UNDEREXCITATION/UNDervOLTAGE FUNCTION TRIP

<u>RPM</u>	<u>% Load</u>	<u>Syst. Faulted</u>	<u>Max. Volts</u>		<u>Chart No.</u>	
			<u>Syst. I</u>	<u>Syst. II</u>	<u>Syst. I</u>	<u>Syst. II</u>
10,000	0	I	339	330	1	1A
10,000	0	II	325	321	A	A1
16,000	0	I	421	433	1B	1C
16,000	0	II	423	428	A2	A3
18,000	0	I	423	427	1D	1E
18,000	0	II	346	341	A4	A5
10,000	50	I	INDETERMINATE		2	2A
10,000	50	II	INDETERMINATE		B	B1
16,000	50	I	INDET.	303	2B	2C
16,000	50	II	399	372	B2	B3
18,000	50	I	420	312	2D	2E
18,000	50	II	403	396	B4	B5
10,000	100	I	INDETERMINATE		3	3A
10,000	100	II	INDETERMINATE		C	C1
16,000	100	I	INDETERMINATE		3B	3C
16,000	100	II	INDETERMINATE		C2	C3
18,000	100	I	INDETERMINATE		3D	3E
18,000	100	II	INDETERMINATE		C4	C5

EXPERIMENTAL LABORATORY TEST RECORD

E.W.O. 54805 MODEL NO. SYSTEMS I + II SERIAL NO. 557 TESTED BY R. J. SAVINUK
DATE OF TEST 12/23/88 TEST LETTER: NO. QP 387

BRUSH GRADE _____ BAR. PRESSURE _____ M.P. AIR GAP _____ I.P. AIR GAP _____

PABA. NO.	TIME	AMB. TEMP.	UNDER EXCITATION / UNDER VOLTAGE FUNCTIONAL TRIP										PAGE	OF
10000 SYS	I	Faulted	Chart 1	No Load 0%	Chart A								SYS I	
10000 SYS	II	—	Chart 1A	No Load 0%	Chart A1								SYS II	
16000 SYS	I	Faulted	Chart 1B	No Load 0%	Chart A2								SYS I	
16000 SYS	II	—	Chart 1C	No Load 0%	Chart A3								SYS II	
18000 SYS	I	Faulted	Chart 1D	No Load 0%	Chart A4								SYS I	
18000 SYS	II	—	Chart 1E	No Load 0%	Chart A5								SYS II	
10000 SYS	I	Faulted	Chart 2	Load 83.5A 50%	Chart B								SYS I	
10000 SYS	II	—	Chart 2A	Load 83.5A 50%	Chart B1								SYS II	
16000 SYS	I	Faulted	Chart 2B	Load 83.5A 50%	Chart B2								SYS I	
16000 SYS	II	—	Chart 2C	Load 83.5A 50%	Chart B3								SYS II	
18000 SYS	I	Faulted	Chart 2D	Load 83.5A 50%	Chart B4								SYS I	
18000 SYS	II	—	Chart 2E	Load 83.5A 50%	Chart B5								SYS II	
10000 SYS	I	Faulted	Chart 3	Load 167A 100%	Chart C								SYS I	
10000 SYS	II	—	Chart 3A	Load 167A 100%	Chart C1								SYS II	
16000 SYS	I	Faulted	Chart 3B	Load 167A 100%	Chart C2								SYS I	
16000 SYS	II	—	Chart 3C	Load 167A 100%	Chart C3								SYS II	
18000 SYS	I	Faulted	Chart 3D	Load 167A 100%	Chart C4								SYS I	
18000 SYS	II	—	Chart 3E	Load 167A 100%	Chart C5								SYS II	

TRANSIENT DUE TO SWITCH CHATTER

OUTPUT VOLTS

EXCITOR CURRENT

OUTPUT AMPS

RANGES: 67.32V 50.00mV 50.00mV

OFFSETS: 0.0V 0.0V 0.0V

TOTAL TIME: 10.00S

POST-TRIG: 0.0S

TRIGGER: EXT

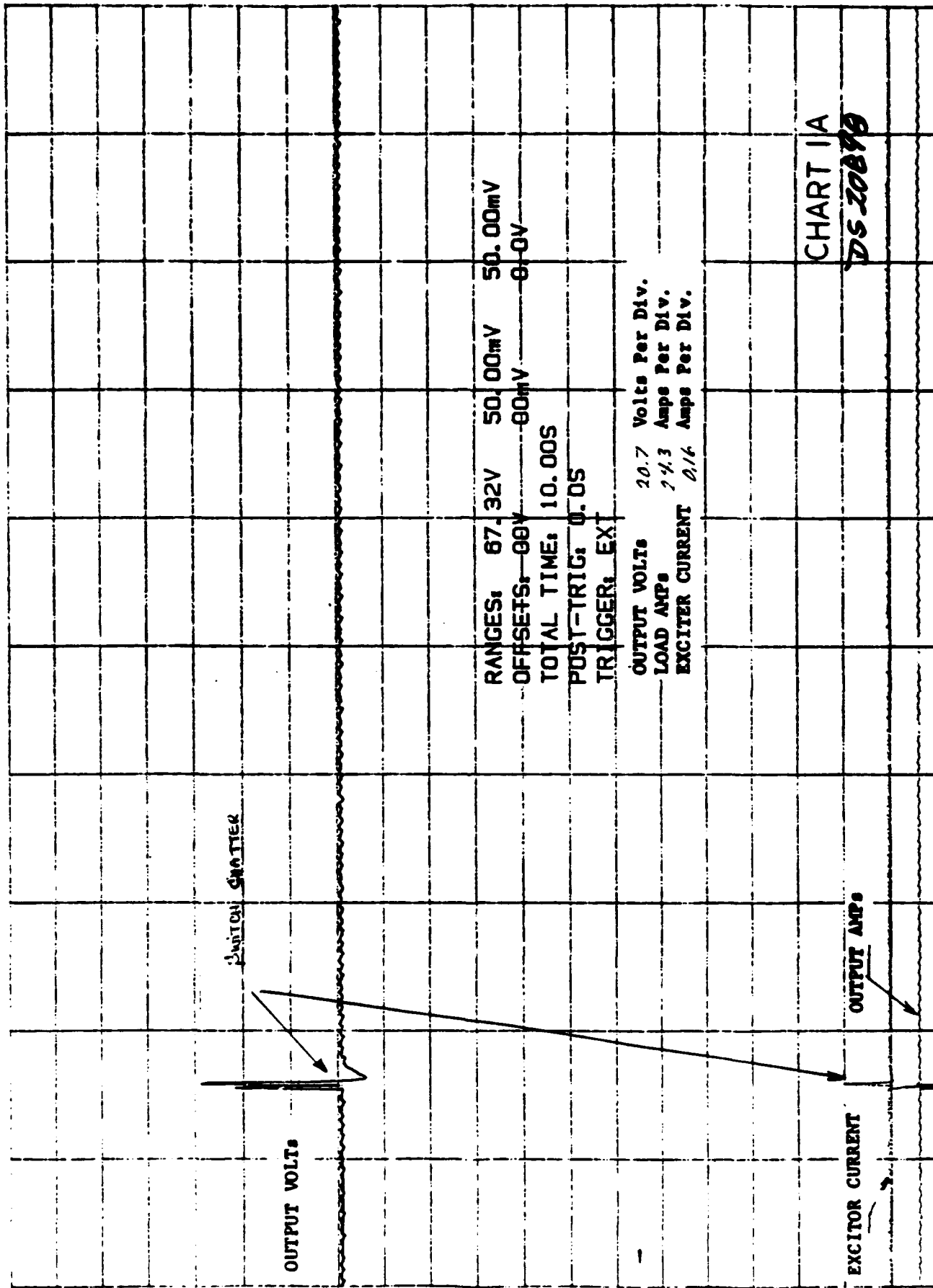
OUTPUT VOLTS 20.17 Volts Per Div.

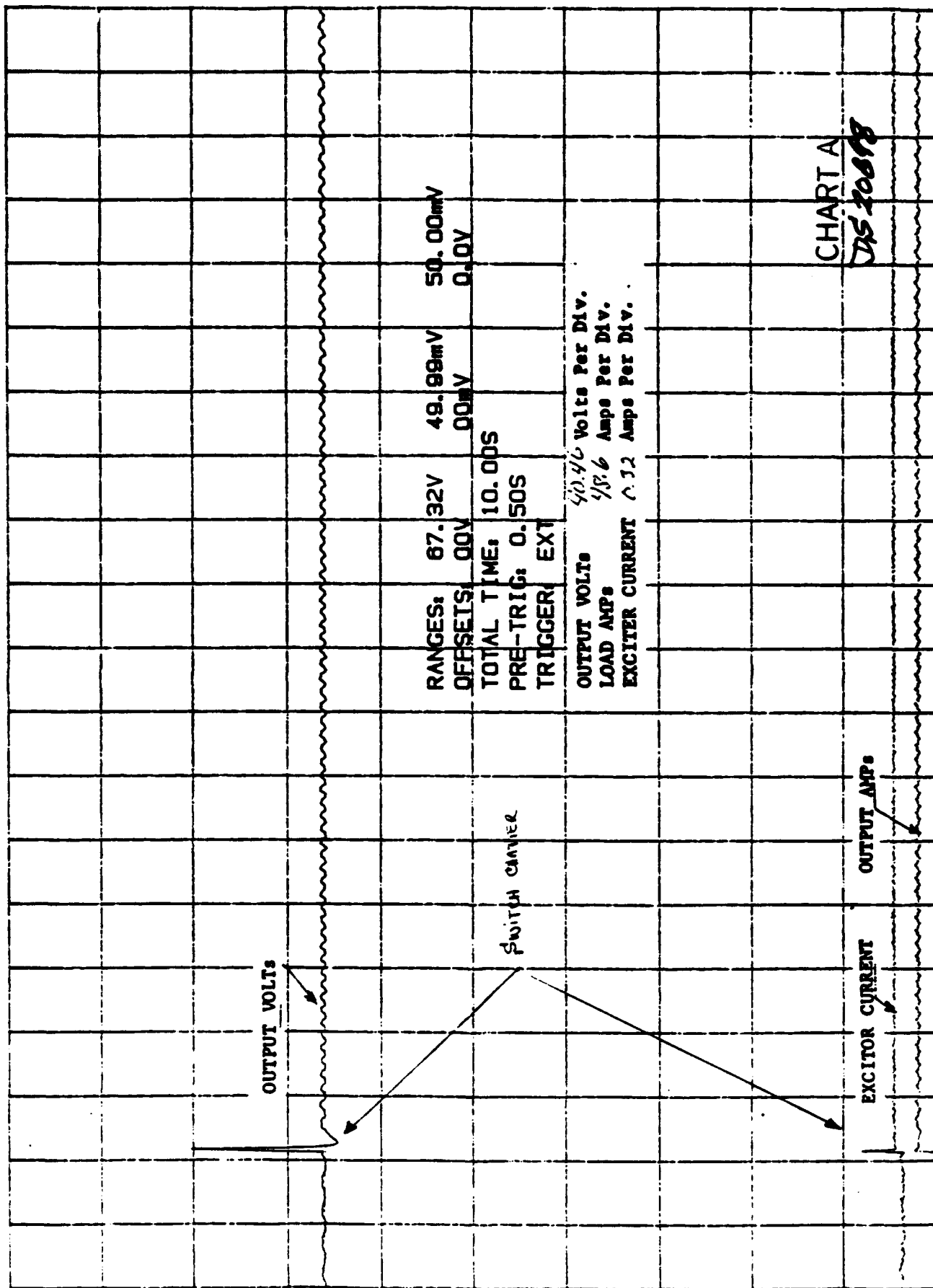
LOAD AMPS 24.3 Amps Per Div.

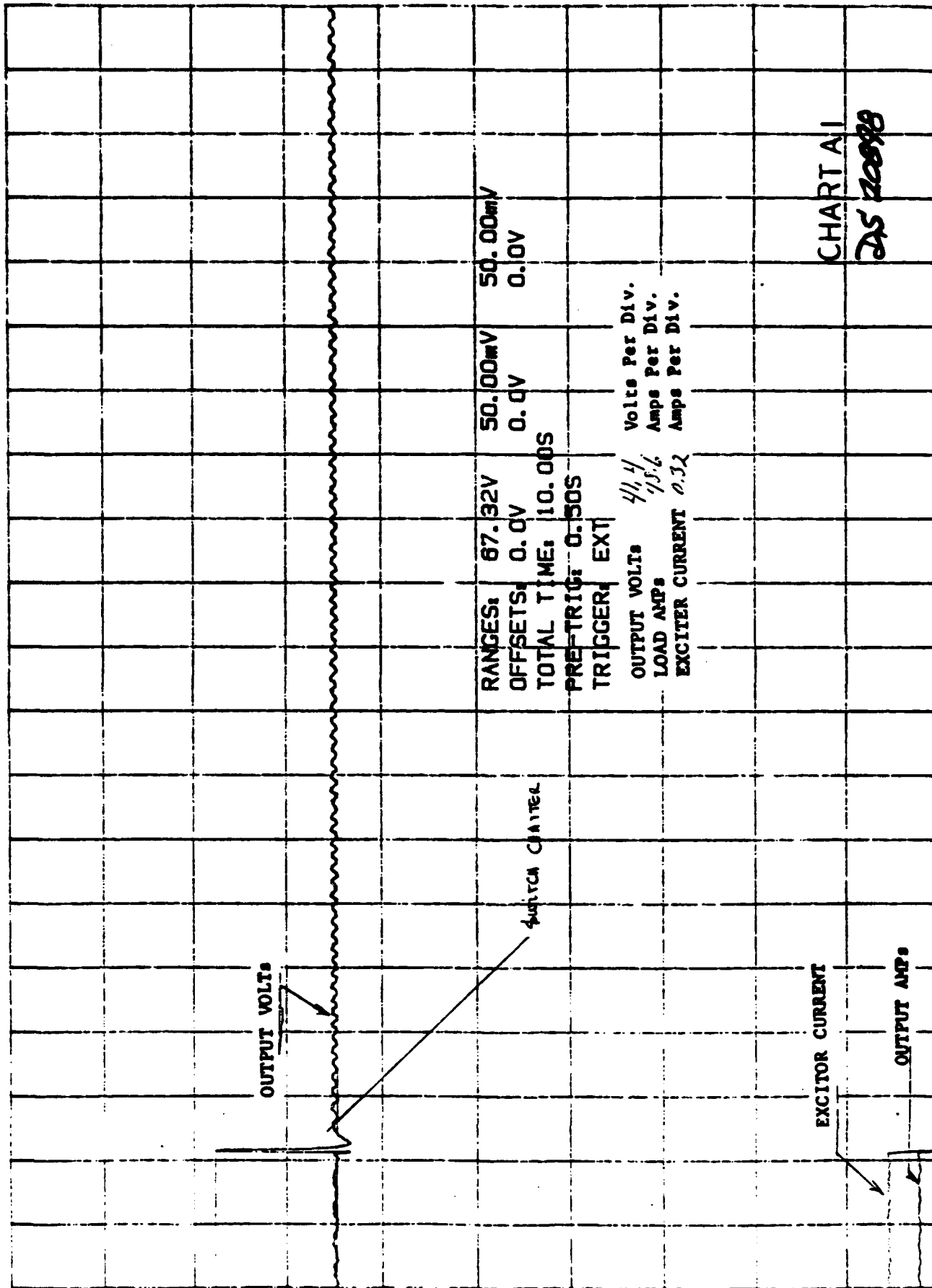
EXCITER CURRENT 0.16 Amps Per Div.

CHART II

75 20898







OUTPUT VOLTS

EXCITOR CURRENT

OUTPUT AMPS

RANGES: 67.32V 50.00mV 50.00mV
OFFSETS: 0.0V 0.0V 0.0V
TOTAL TIME: 10.00S
POST-TRIG: 0.0S
TRIGGER: EXT

OUTPUT VOLTS 20.23 Volts Per Div.
LOAD AMPS 24.3 Amps Per Div.
EXCITER CURRENT 0.16 Amps Per Div.

CHART 1B

DS 2089B

OUTPUT VOLTS

EXCITOR CURRENT

OUTPUT AMPs

RANGES: 67.32V 50.00mV 50.00mV 50.00mV
OFFSETS: 00V 00mV 00mV 0.0V
TOTAL TIME: 10.00S
POST-TRIG: 0.0S
TRIGGER: EXT
OUTPUT VOLTS 20.7 Volts Per Div.
LOAD AMPs 24.3 Amps Per Div.
EXCITER CURRENT 0.16 Amps Per Div.

CHART IC
DS-20078

OUTPUT VOLTS

EXCITOR CURRENT

OUTPUT AMPS

RANGES: 67.32V 50.00mV 50.00mV

OFFSETS: 0.0V 0.0V 0.0V

TOTAL TIME: 10.00S

POST-TRIG: 0.0S

TRIGGER: EXT

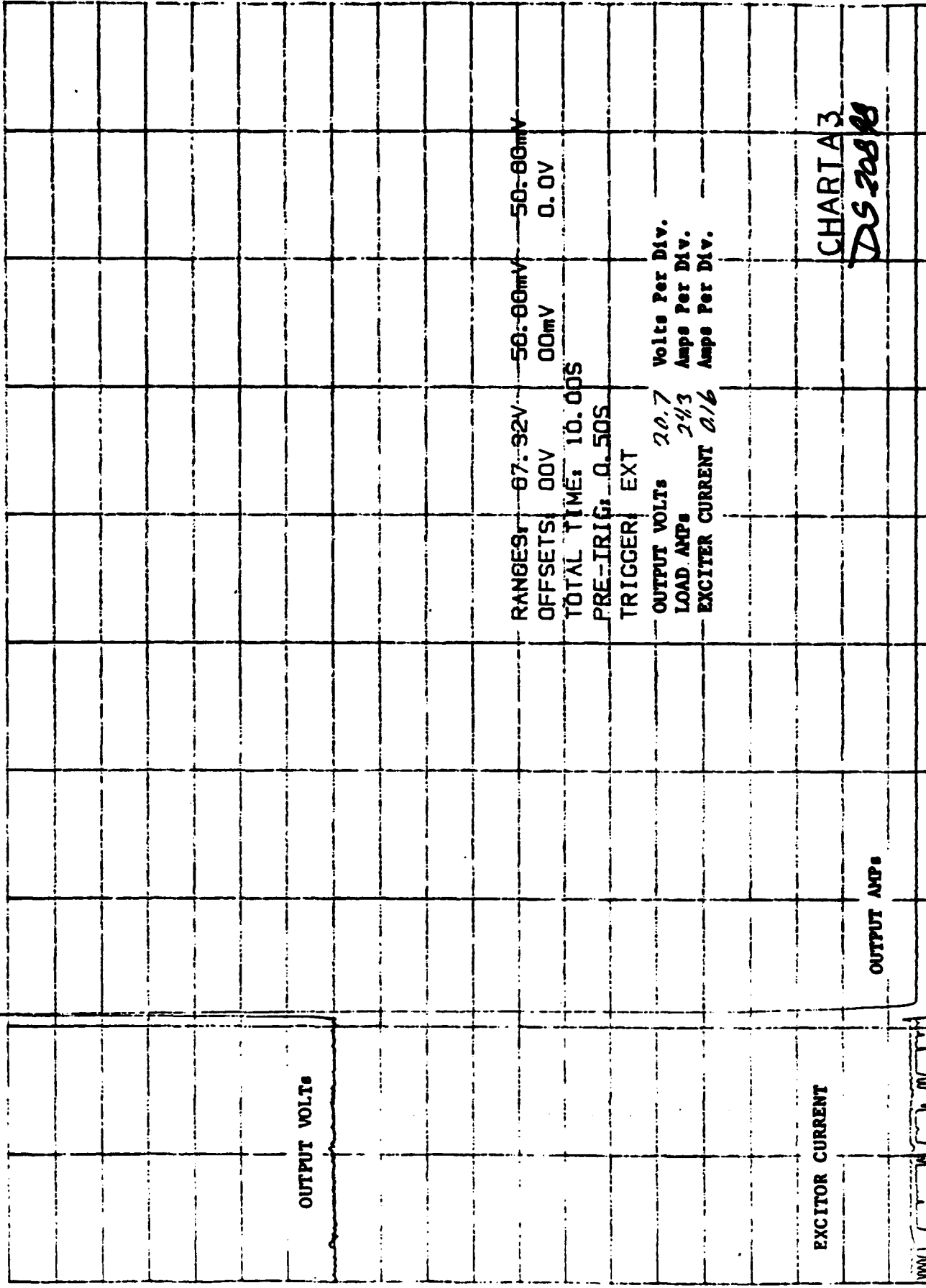
OUTPUT VOLTS 2023 Volts Per Div.

LOAD AMPS 243 Amps Per Div.

EXCITER CURRENT 0.16 Amps Per Div.

CHART A2

DS 20098



OUTPUT VOLTS

EXCITOR CURRENT

OUTPUT AMPs

RANGES: 07.32V 50.00mV 50.00mV
OFFSETS: 00V 00mV 0.0V
TOTAL TIME: 10.00S
PRE-TRIG: 0.50S
TRIGGER: EXT
OUTPUT VOLTS 20.7 Volts Per Div.
LOAD AMPs 24/3 Amps Per Div.
EXCITER CURRENT 0.16 Amps Per Div.

CHART A3
DS 2088

OUTPUT VOLTS

EXCITOR CURRENT

OUTPUT AMPs

RANGES: 67.32V 50.00mV 50.00mV

OFFSETS: 0.0V 0.0V 0.0V

TOTAL TIME: 10.00S

POST-TRIG: 0.0S

TRIGGER: EXT

OUTPUT VOLTS 20.23 Volts Per Div.

LOAD AMPs 2.13 Amps Per Div.

EXCITER CURRENT 0.16 Amps Per Div.

CHART ID

DS 2049B

OUTPUT VOLTS

EXCITOR CURRENT

OUTPUT AMPS

RANGES: 67.32V 50.00mV 50.00mV

OFFSETS: 00V 00mV 0.0V

TOTAL TIME: 10.00S

POST-TRIG: 0.0S

TRIGGER: EXT

OUTPUT VOLTS 10.7 Volts Per Div.

LOAD AMPS 24.3 Amps Per Div.

EXCITER CURRENT 0.16 Amps Per Div.

CHART 1E

DS-20428

OUTPUT VOLTS

EXCITOR CURRENT

OUTPUT AMPs

RANGES: 67.32V 50.00mV 50.00mV
OFFSETS: 0.0V 0.0V 0.0V
TOTAL TIME: 10.00S
POST-TRIG: 0.0S
TRIGGER: EXT

OUTPUT VOLTS 20.23 Volts Per Div.
LOAD AMPs 21.3 Amps Per Div.
EXCITER CURRENT 0.16 Amps Per Div.

CHART A4

DS 2089B

OUTPUT VOLTS

EXCITOR CURRENT

OUTPUT AMPS

RANGES: 67-32V 50.00mV 50.00mV

OFFSETS: 00V 00mV 0.0V

TOTAL TIME: 10.00S

PRE-TRIG: 0.50S

TRIGGER: EXT

OUTPUT VOLTS 20.7 Volts Per Div.

LOAD AMPS 24.3 Amps Per Div.

EXCITER CURRENT 0.16 Amps Per Div.

CHART A5

DS 2098

OUTPUT VOLTS



RANGES: 67.32V 50.00mV 50.00mV

OFFSETS: 00V 00mV 0.0V

TOTAL TIME: 10.00S

PRE-TRIG: 0.50S

TRIGGER: EXT

OUTPUT VOLTS 20.23 Volts Per Div.

LOAD AMPS 24.3 Amps Per Div.

EXCITER CURRENT 0.16 Amps Per Div.

OUTPUT AMPS



EXCITER CURRENT



CHART B

DS 20890

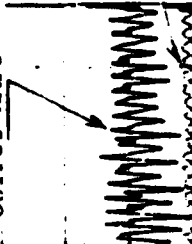
OUTPUT VOLTS



RANGES: 67.32V 50.00mV 50.00mV
OFFSETS: 0.0V 0.0V 0.0V
TOTAL TIME: 10.00S
POST-TRIG: 0.0S
TRIGGER: EXT

OUTPUT VOLTS 20V Volts Per Div.
LOAD AMPS 2 1/3 Amps Per Div.
EXCITER CURRENT 0.16 Amps Per Div.

OUTPUT AMPS



EXCITOR CURRENT

CHART B1

DS 20898

OUTPUT VOLTS



RANGES: 67.32V 50.00mV 50.00mV
OFFSETS: 0.0V 0.0V 0.0V
TOTAL TIME: 10.00S
POST-TRIG: 0.0S
TRIGGER: EXT

OUTPUT VOLTS 20.23 Volts Per Div.
LOAD AMPS 2.13 Amps Per Div.
EXCITER CURRENT 0.16 Amps Per Div.

OUTPUT AMP



EXCITOR CURRENT

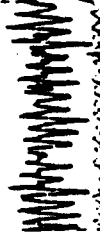


CHART 2
DS 2008B

RANGES: 67.32V 50.00mV 50.00mV
OFFSETS: 00V 00mV 0.0V
TOTAL TIME: 10.00S
PRE-TRIG: 0.50S
TRIGGER: EXT

OUTPUT VOLTS 20.7 Volts Per Div.
LOAD AMPS 24.3 Amps Per Div.
EXCITER CURRENT 0.16 Amps Per Div.

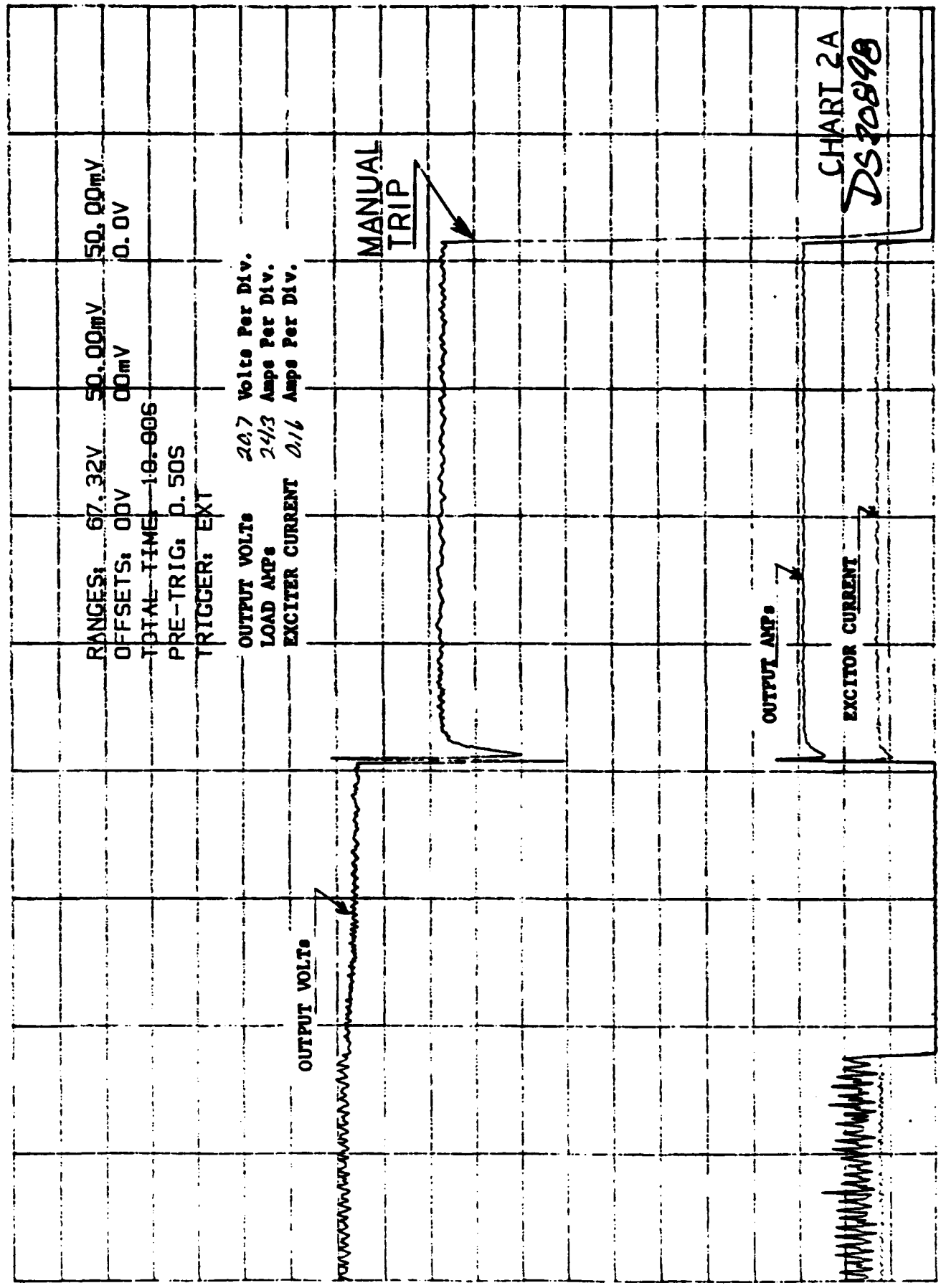
OUTPUT VOLTS

MANUAL
TRIP

OUTPUT AMPS

EXCITER CURRENT

CHART 2A
DS 20898



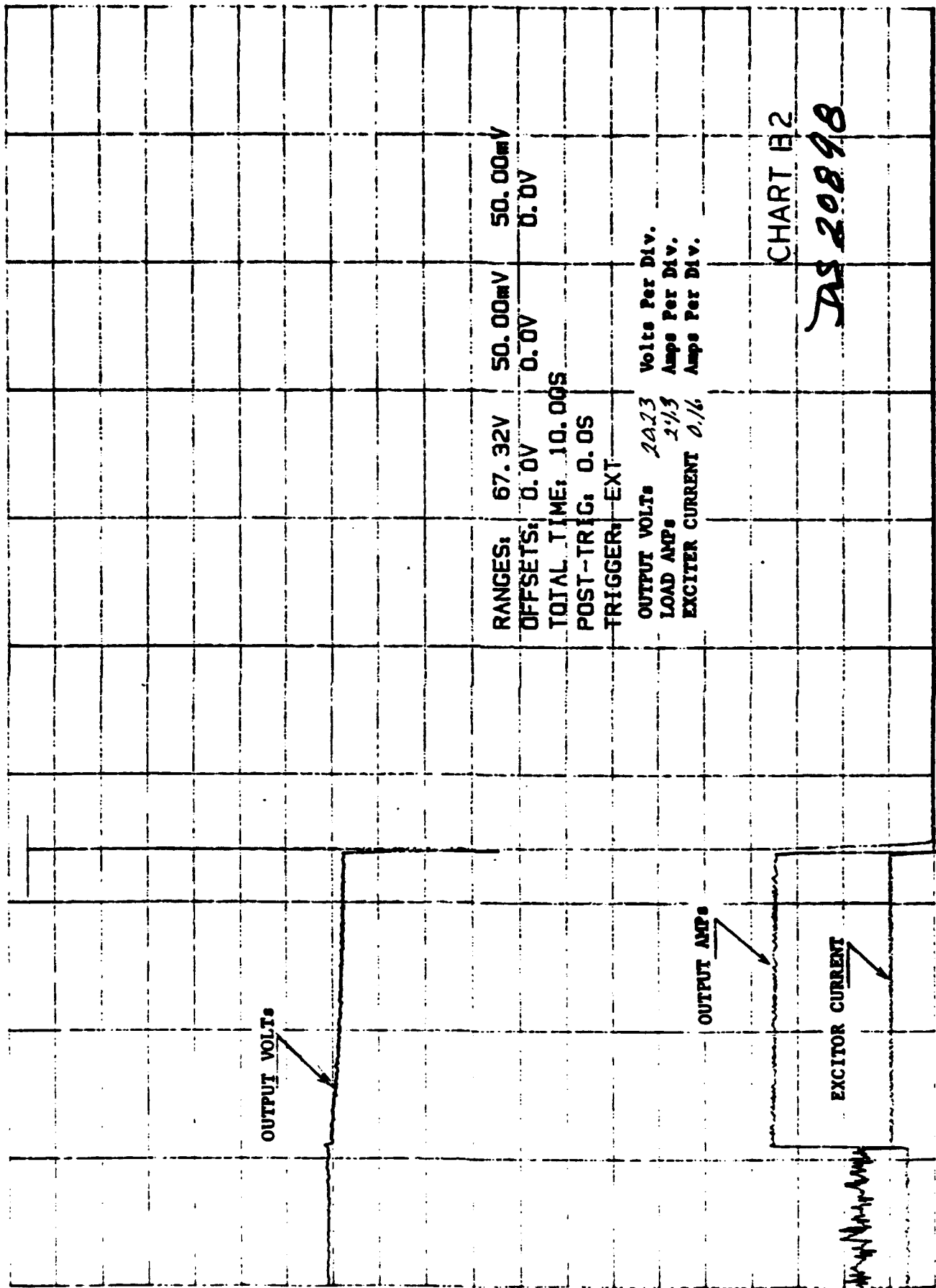
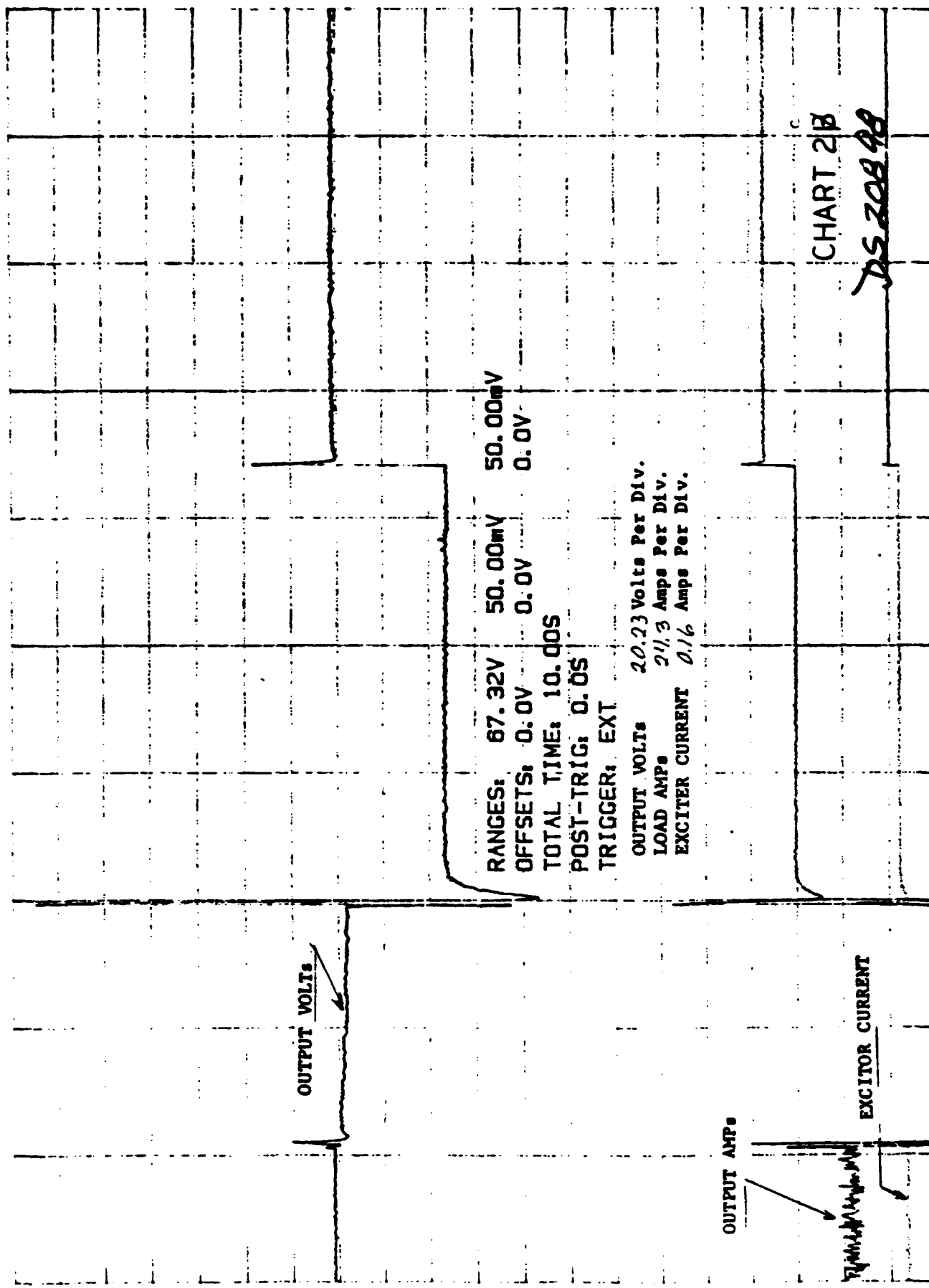


CHART H2

AS 20898



RANGES: 67.32V 50.00mV 50.00mV
OFFSETS: 0.0V 0.0V 0.0V
TOTAL TIME: 10.00S
POST-TRIG: 0.0S
TRIGGER: EXT
OUTPUT VOLTS 20.23 Volts Per Div.
LOAD AMPs 21.3 Amps Per Div.
EXCITER CURRENT 0.16 Amps Per Div.

CHART 218

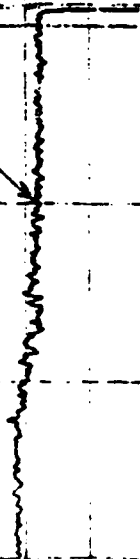
DS 20898

OUTPUT VOLTS

OUTPUT AMPs

EXCITER CURRENT

OUTPUT VOLTS



RANGES: 67.32V 50.00mV 50.00mV
OFFSETS: 0.0V 0.0V 0.0V
TOTAL TIME: 10.00S
POST-TRIG: 0.0S
TRIGGER: EXT

OUTPUT VOLTS 20.23 Volts Per Div.
LOAD AMPs 21.3 Amps Per Div.
EXCITER CURRENT 0.16 Amps Per Div.

OUTPUT AMPs



EXCITER CURRENT

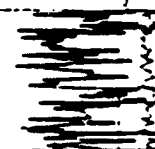
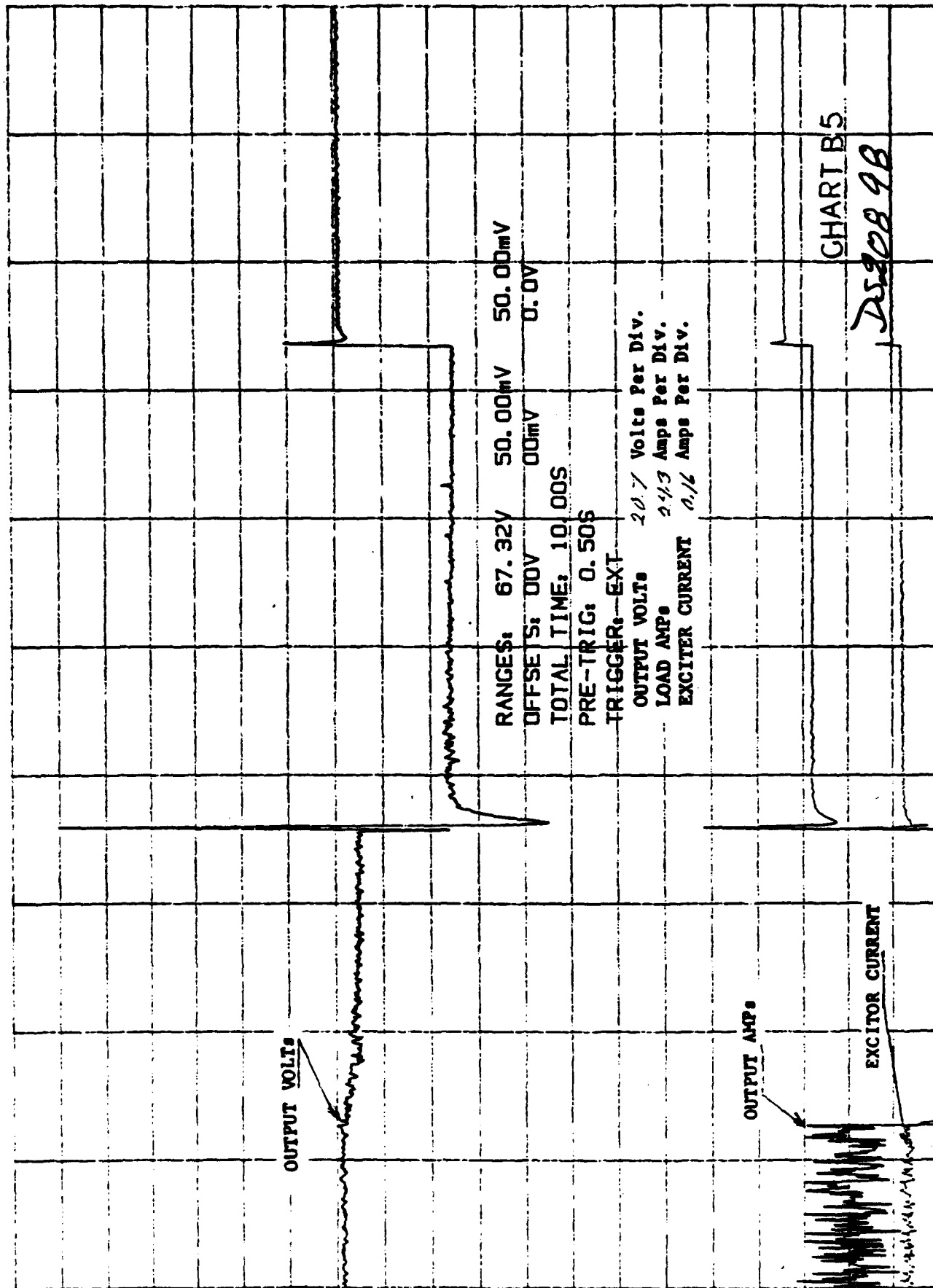
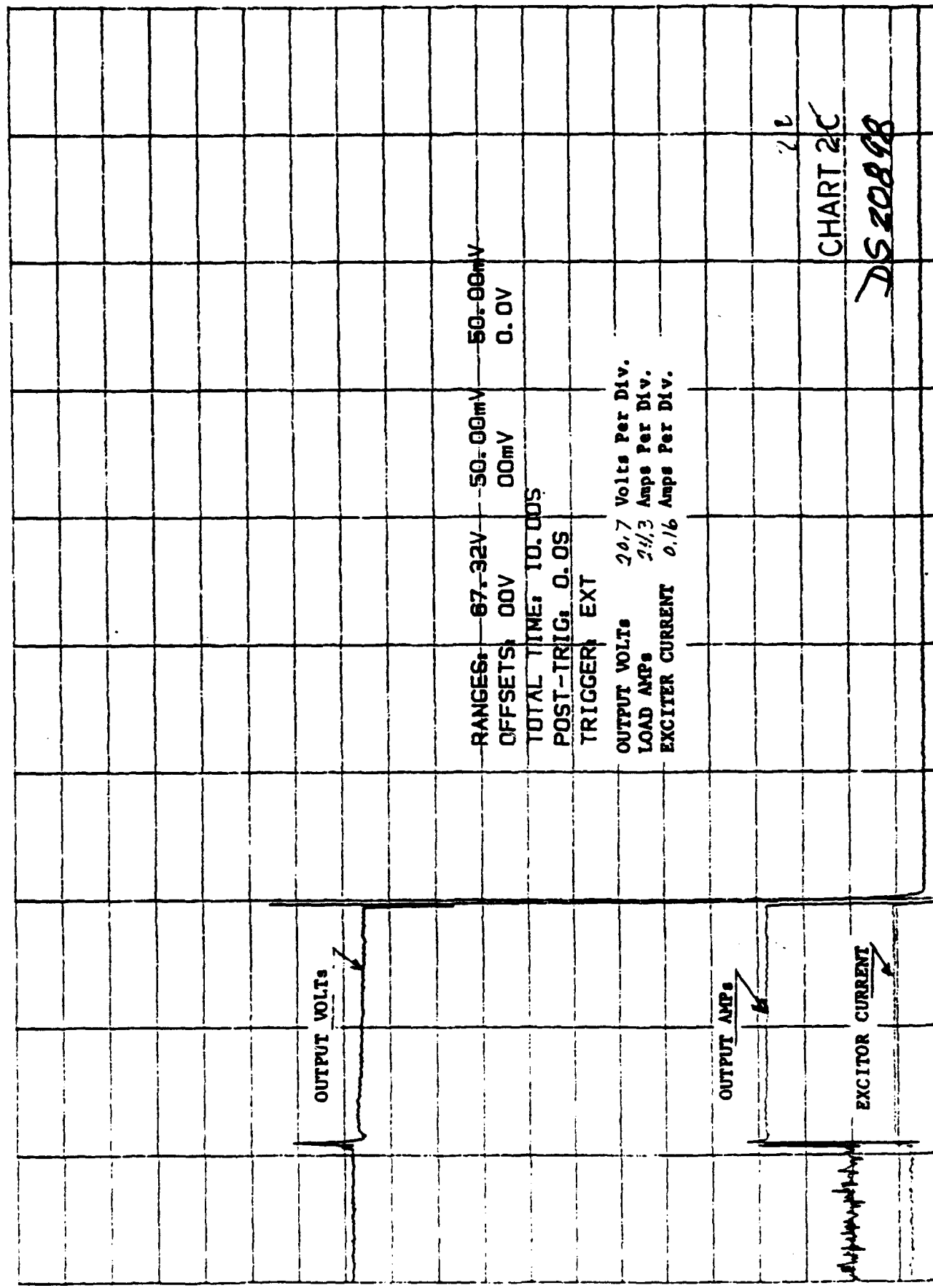


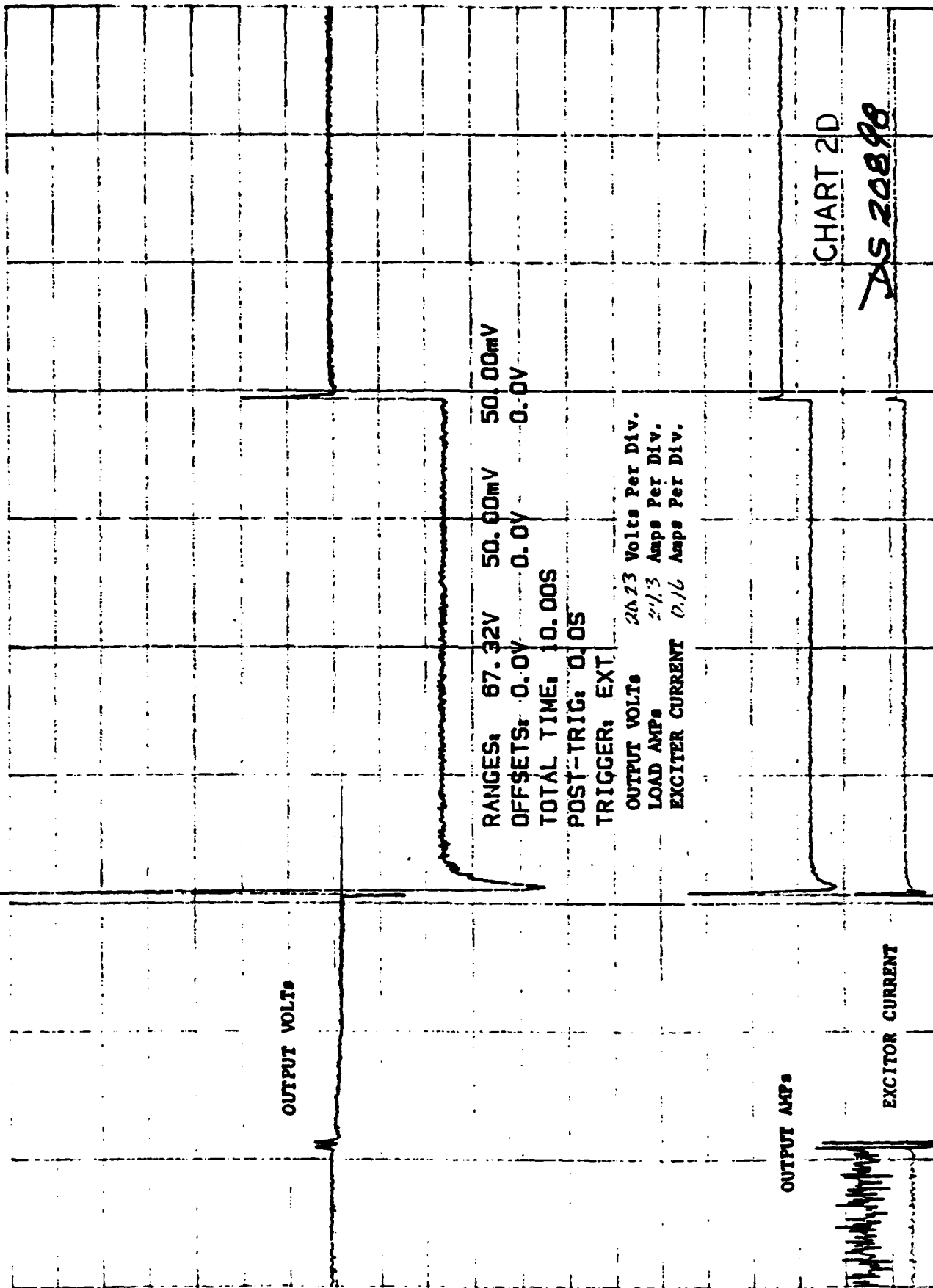
CHART B4

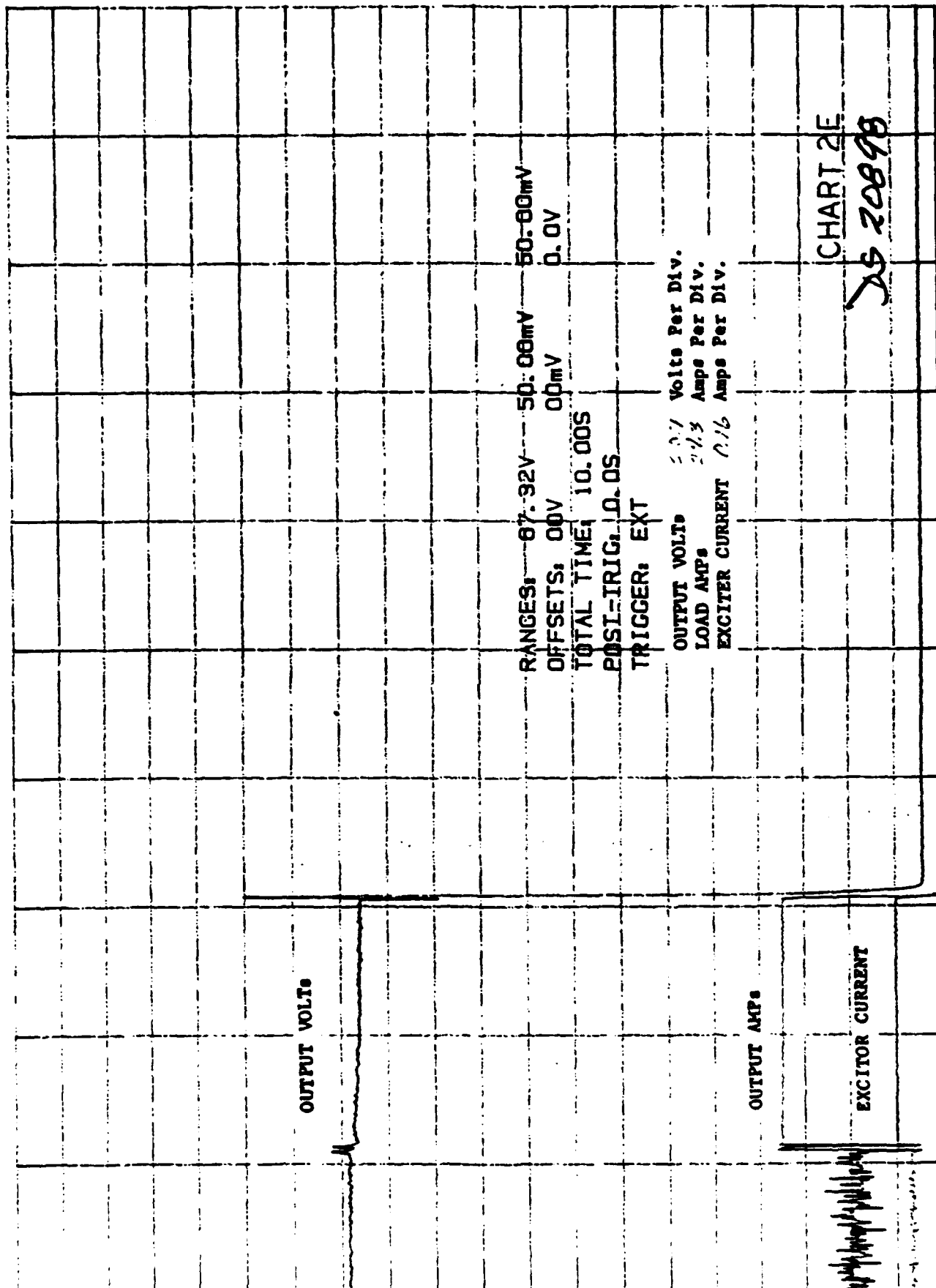
DS2088

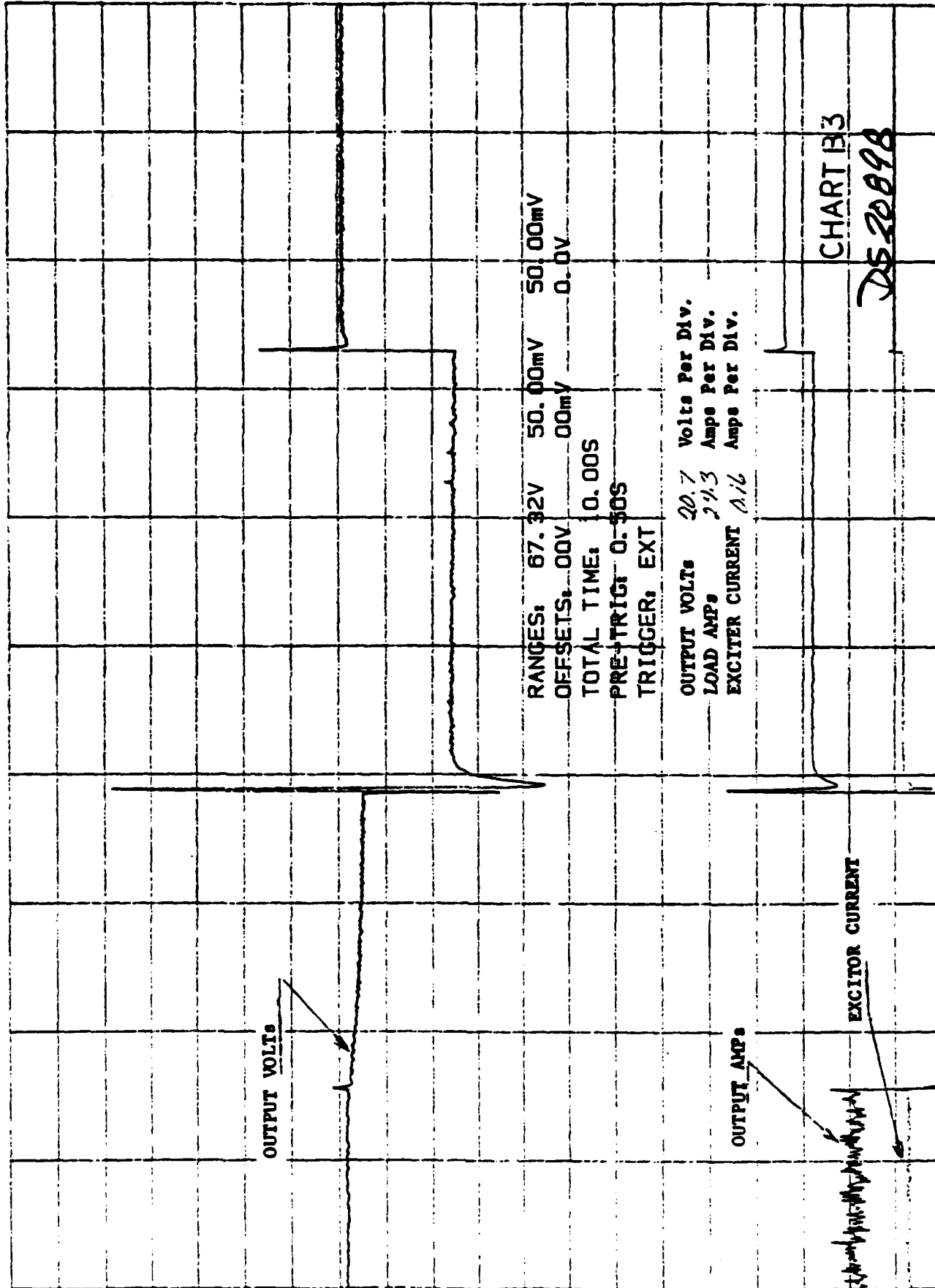




72
CHART 2C
DS 20898







OUTPUT VOLTS

RANGES: 67.32V 50.00mV 50.00mV
OFFSETS: 0.0V 0.0V 0.0V
TOTAL TIME: 10.00S
POST-TRIG: 0.0S
TRIGGER: EXT

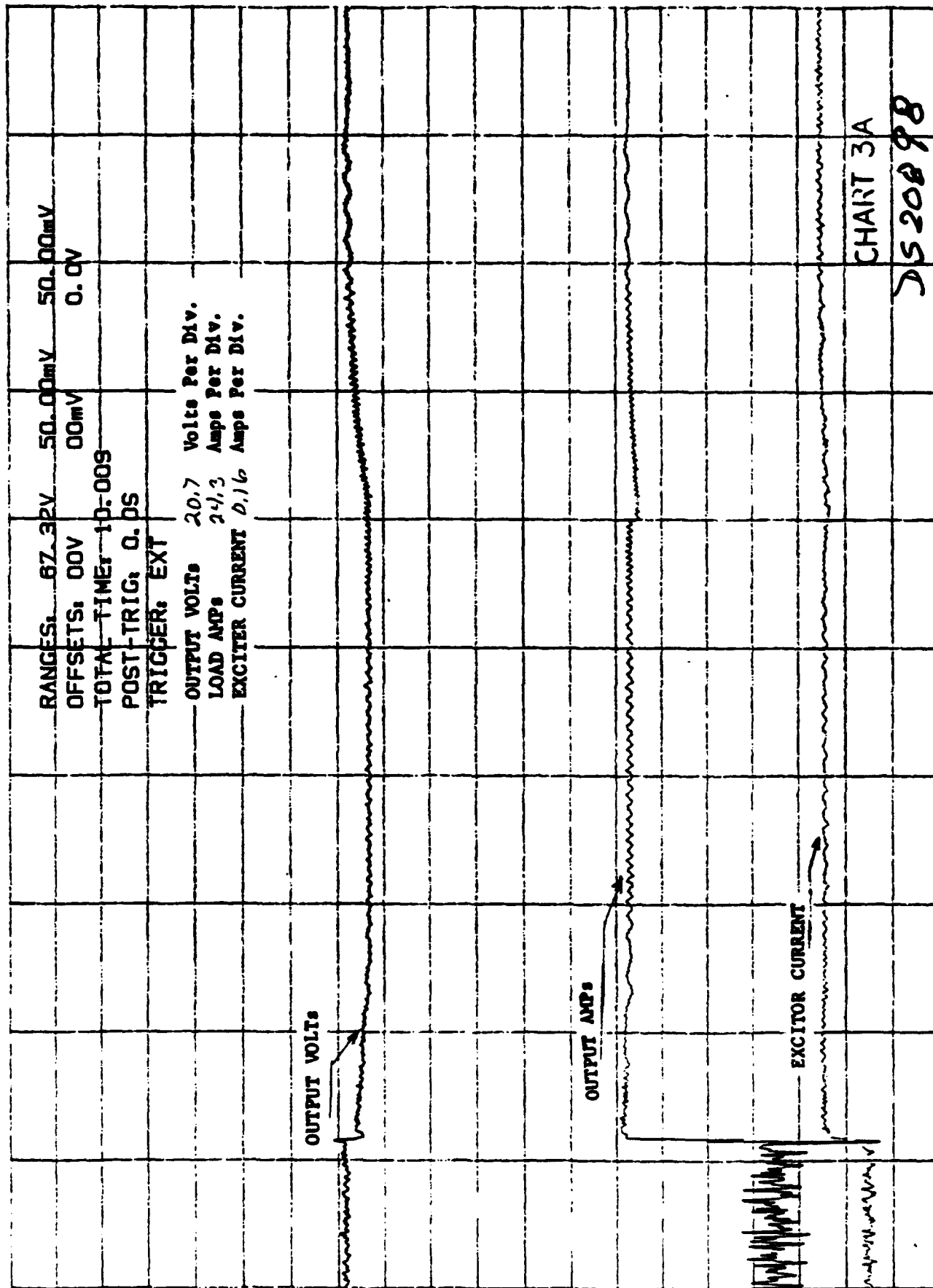
OUTPUT AMPs

EXCITOR CURRENT

OUTPUT VOLTS 20.23 Volts Per Div.
LOAD AMPs 2.13 Amps Per Div.
EXCITER CURRENT 0.16 Amps Per Div.

CHART 3

DS 2089B



RANGES: 67.32V 50.00mV 50.00mV

OFFSETS: 0.0V 0.0V 0.0V

TOTAL TIME: 10.00S

POST-TRIG: 0.0S

TRIGGER: EXT

OUTPUT VOLTS 20.23 Volts Per Div.

LOAD AMPS 24.3 Amps Per Div.

EXCITER CURRENT 0.16 Amps Per Div.

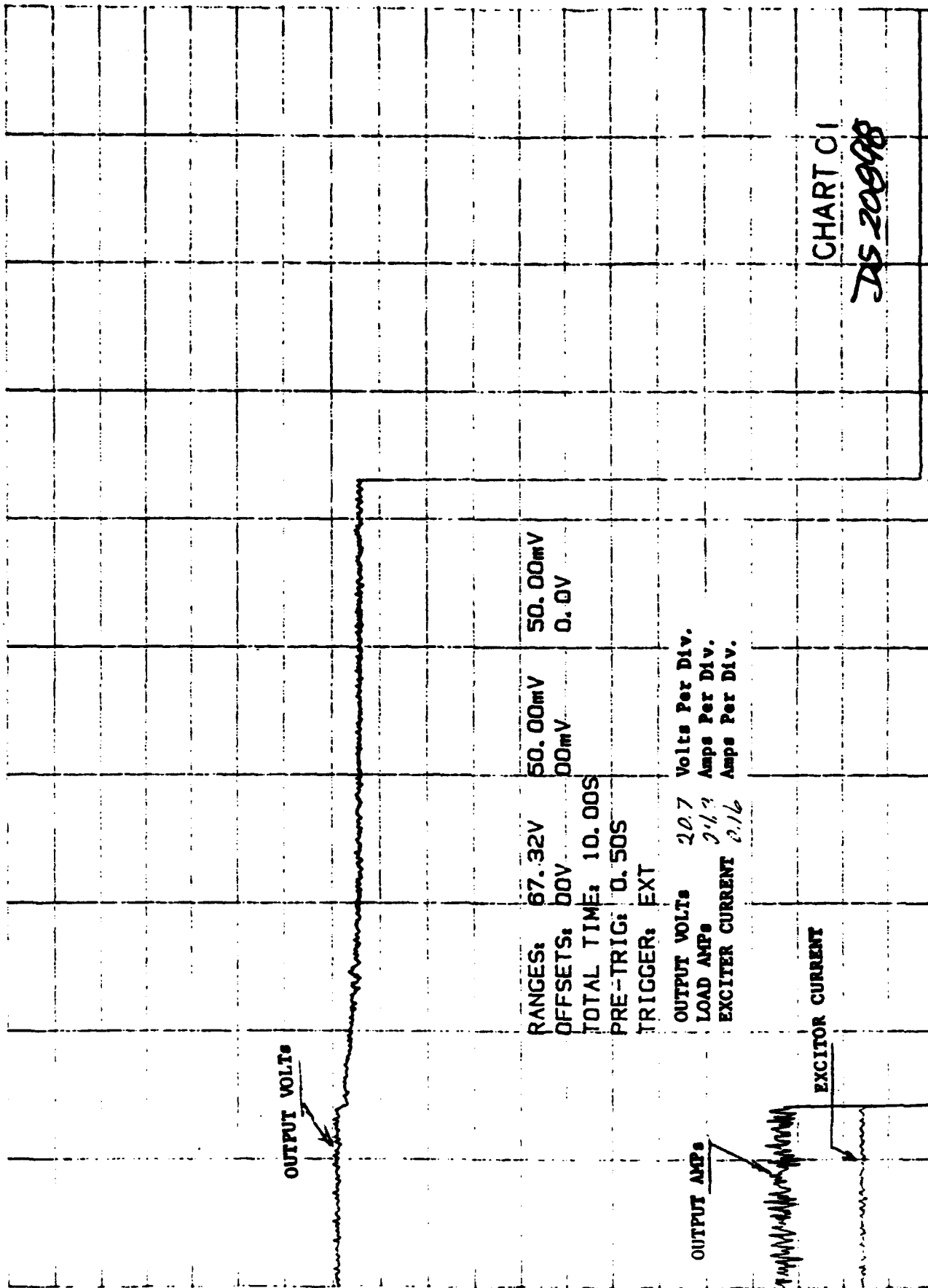
OUTPUT VOLTS

OUTPUT AMPS

EXCITER CURRENT

CHART C

PS 20898



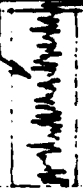
OUTPUT VOLTS



RANGES: 67.32V 50.00mV 50.00mV
OFFSETS: 0.0V 0.0V 0.0V
TOTAL TIME: 10.00S
POST-TRIG: 0.0S
TRIGGER: EXT

OUTPUT VOLTS 20.23 Volts Per Div.
LOAD AMPS 2.43 Amps Per Div.
EXCITOR CURRENT 2.16 Amps Per Div.

OUTPUT AMPS



EXCITOR CURRENT

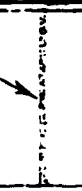


CHART 3B
DS 20898

OUTPUT VOLTS

RANGES: 87.32V 50.00mV 50.00mV
OFFSETS: 00V 00mV 0.0V

TOTAL TIME: 10.00S

POST-TRIG: 0.0S

TRIGGER: EXT

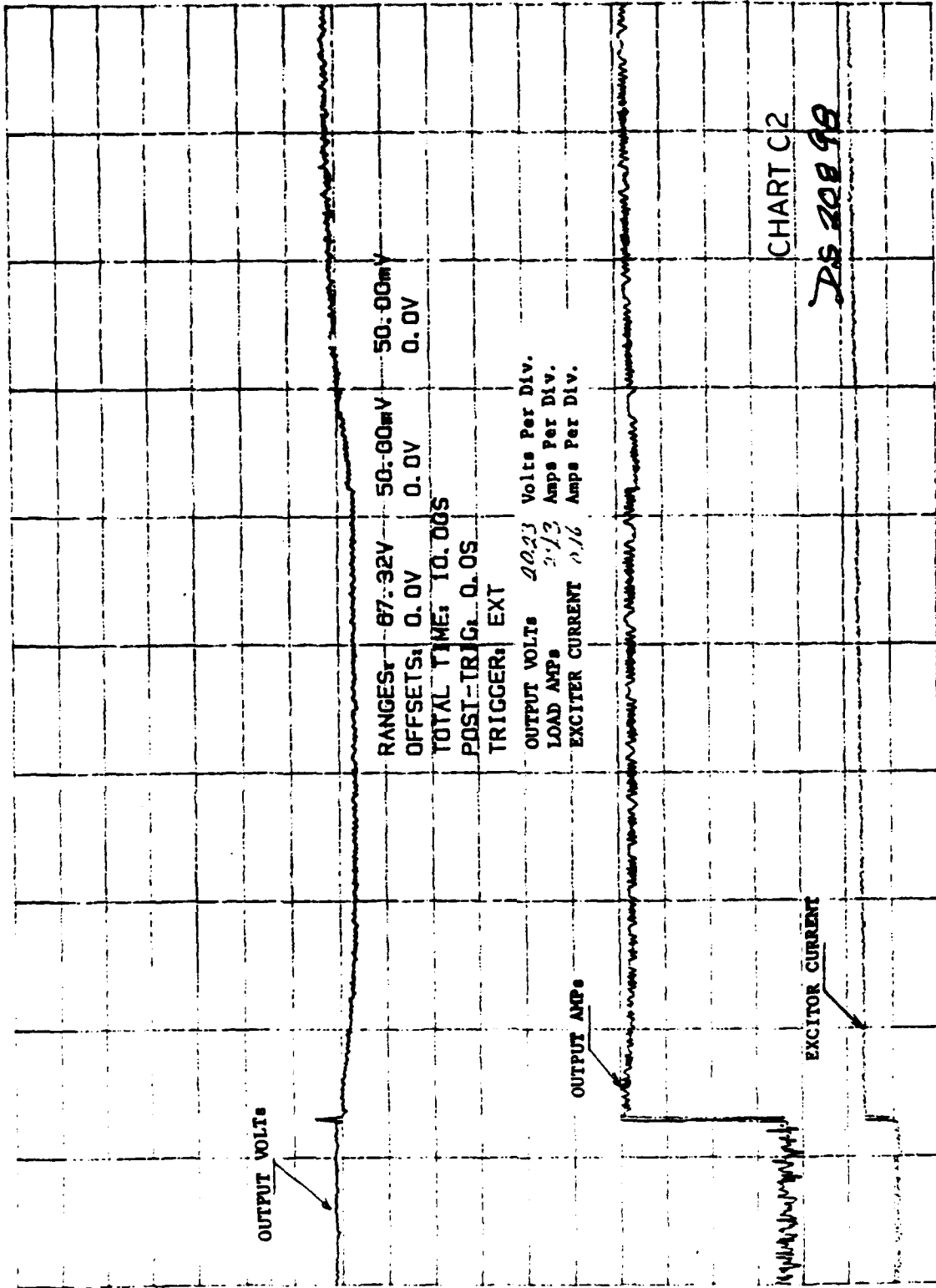
OUTPUT VOLTS 20.7 Volts Per Div.
LOAD AMPS 21.3 Amps Per Div.
EXCITER CURRENT 0.16 Amps Per Div.

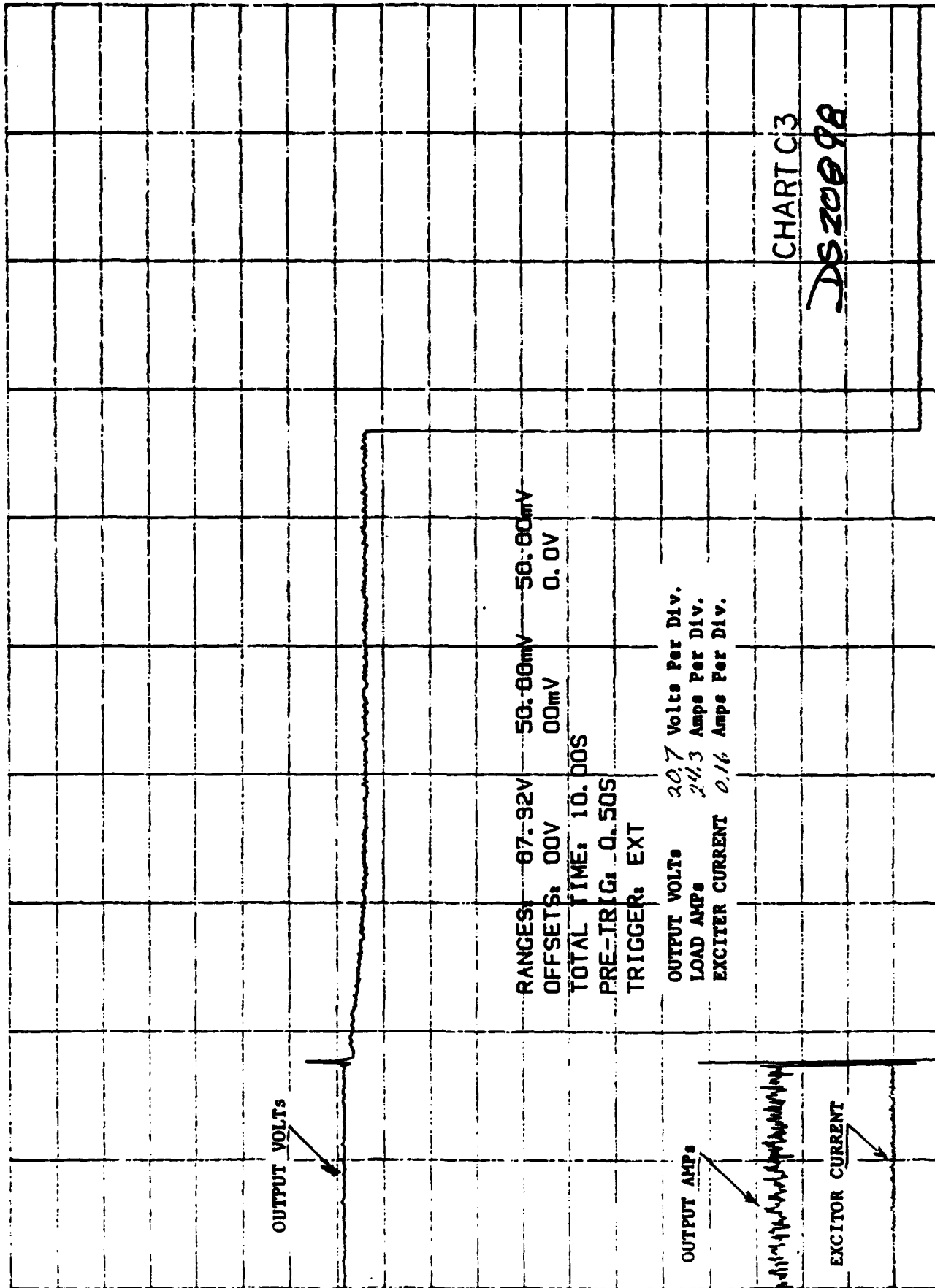
OUTPUT AMPS

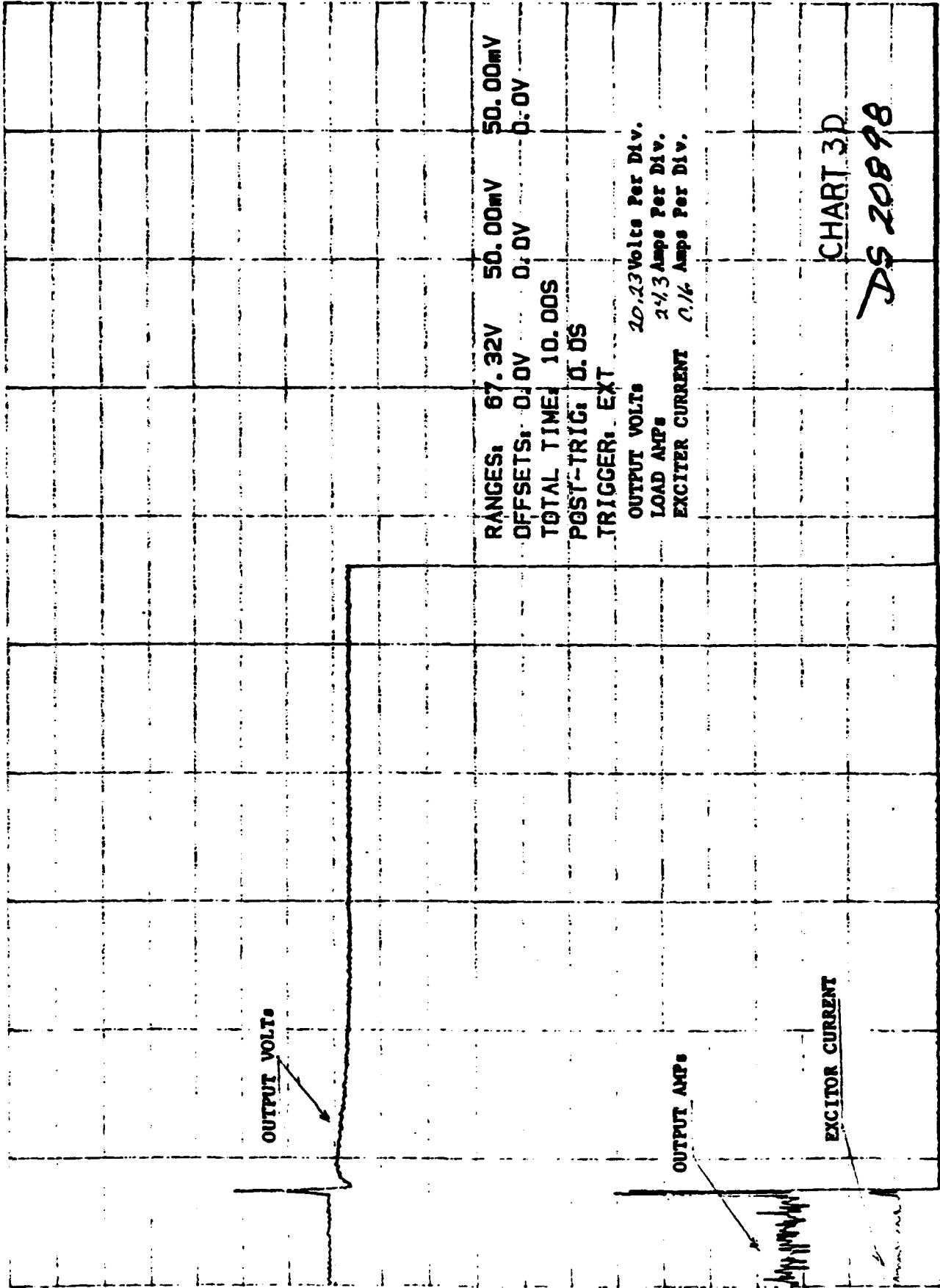
EXCITER CURRENT

CHART 3C

DS 20898







RANGES: 67.32V 50.00mV 50.00mV

OFFSETS: 0.0V 0.0V 0.0V

TOTAL TIME: 10.00S

POST-TRIG: 0.0S

TRIGGER: EXT

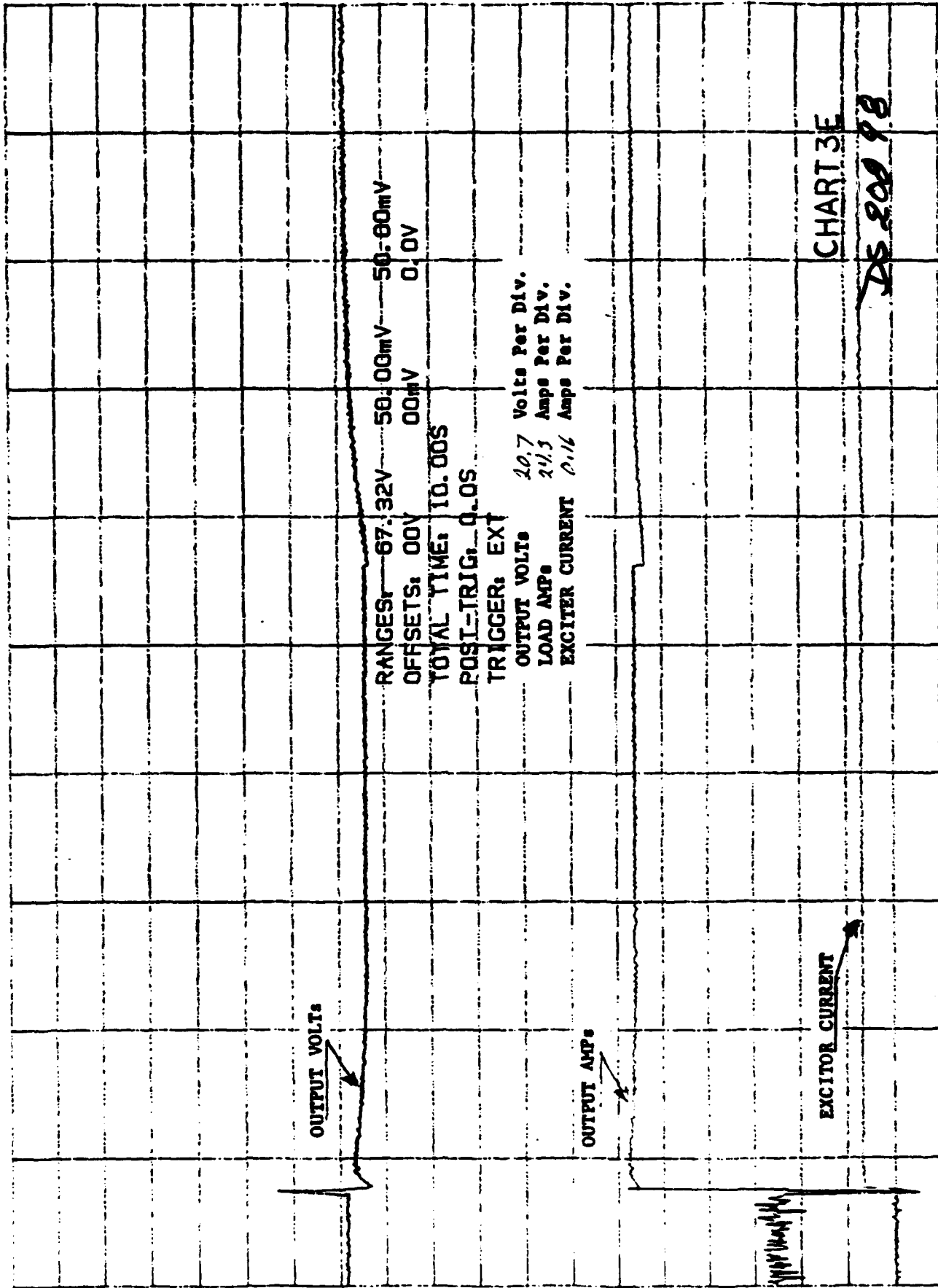
OUTPUT VOLTS 20.23Volts Per Div.

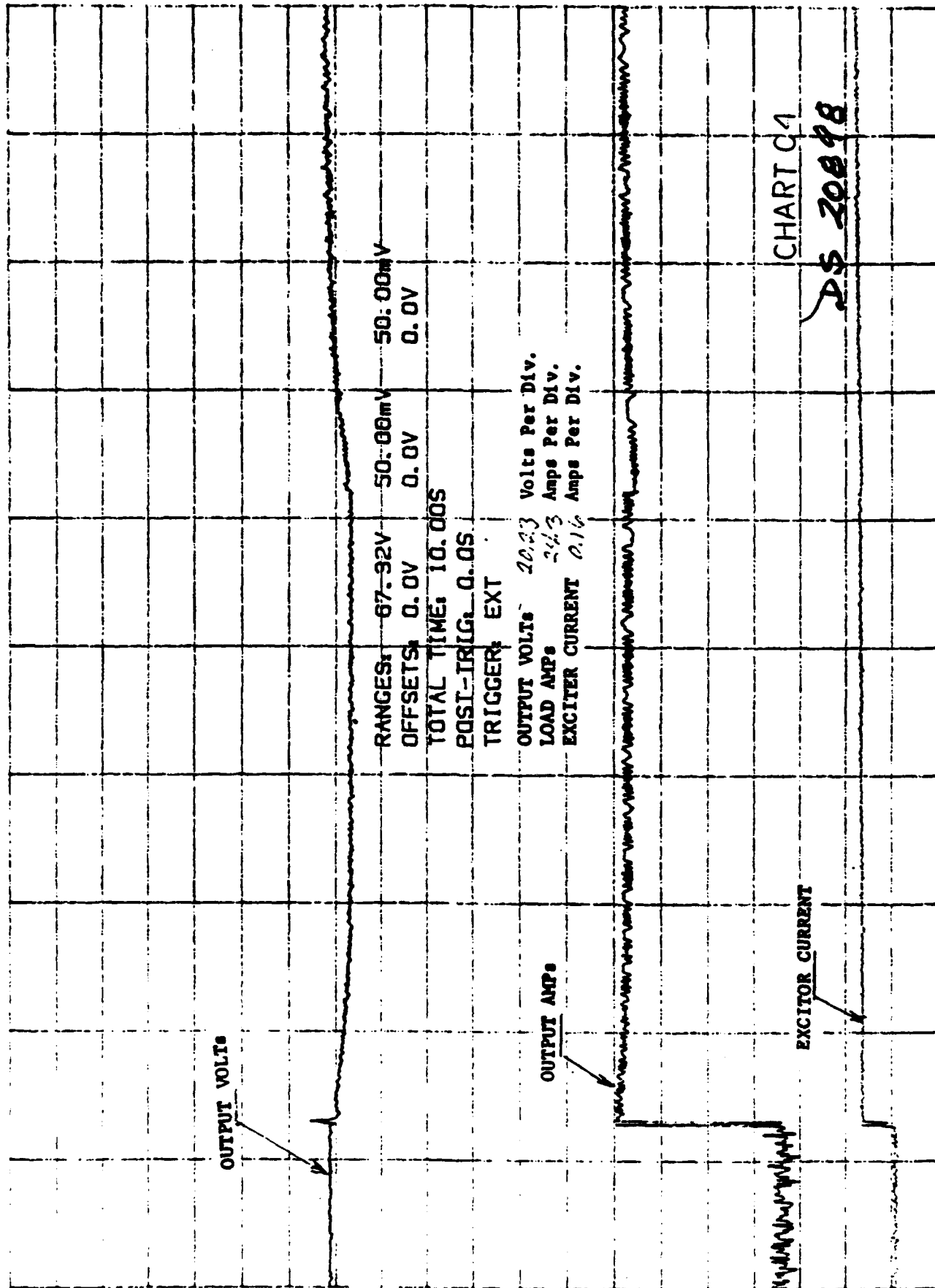
LOAD AMPs 24.3Amps Per Div.

EXCITER CURRENT 0.16Amps Per Div.

CHART 3D

DS 20898





5.11

Protection Performance

Purpose: the purpose of the series of tests performed was to confirm that system protection circuitry functioned properly.

Procedure: The tests required to demonstrate protection performance were done according to the acceptance test procedure for the 51527-000 generator control unit. A copy of the test procedure, LAPEC specification 17-510121, is appended to this section.

Results: Test results are shown on: LAPEC data sheets 19932 through 19940 for unit serial number 103; LAPEC data sheets 22042 through 22050 for unit serial number 104.

Discussion of Results: The test data indicates, that the GCU's performed in accordance with the requirements specified by the preliminary test specification 17-510121.

REVISIONS

REV	DESCRIPTION	DATE	APPROVED
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DWG NO. 17-510121

P E

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RELEASED BY: C. B. Olmick DATE: 8/16/85

REV																																							
SHEET		35	36	37	38	39	40	41	42	43	44	45	46	47	48	49	50	51	52	53	54	55	56	57	58	59	60	61	62	63	64	65	66	67	68	69	70	71	72
REV STATUS																																							
SHEET		1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28	29	30	31	32	33	34				
UNLESS OTHERWISE SPECIFIED DIMENSIONS ARE IN INCHES TOLERANCE ON DECIMALS ANGLES XX - 01 XXX - 005 .0 30'		CONTRACT NO. _____										<div> <div>Lucas Aerospace</div> <div>Lucas Aerospace Power Equipment Corporation</div> </div>																											
DO NOT SCALE THIS DRAWING		DRAWN BY _____ DATE _____										CHECKED BY _____										Acceptance Test Procedure for 51527-000 Generator Control Unit																	
MATERIAL		MATEL APVD _____										COMPNT ENGR _____										<div> <div>SIZE</div> <div>FSCM NO.</div> <div>DWG. NO.</div> </div>																	
		MECH ELECT CSGN APVD _____										PROJECT ENGR _____										<div> <div>A</div> <div>31435</div> <div>17-510121</div> </div>																	
		SCALE _____										SHEET 1 OF 10																											

1.0

SCOPE

1.1 This specification establishes the acceptance test requirements for the Generator Control Unit (GCU) for controlling 270 volt direct current generator. Such a system is defined as a single or isolated system. Two or more of these systems connected to the same load bus constitute a parallel system. This system is designed to meet Specification No. NADC-60-TS-7803 of the Department of the Navy.

1.2

Type

The Generator Control Unit and the associated current sensor assemblies shall be self cooled and designed to maintain a constant generator output voltage and provide equal load distribution in a parallel generator system.

2.

APPLICABLE DOCUMENTS

The following documents from a part of this specification to the extent specified herein.

SPECIFICATIONS

Federal

NADC-60-TS-7803

Generator System, 270 VDC
Oil Cooled, Aircraft,
General Specification for

Military

MIL-T-704

Treatment and Painting of
Material

MIL-D-1000

Drawings, Engineering and
Associated Lists

STANDARDS

Military

MIL-STD-129

Marking for Shipment
and Storage

MIL-STD-130

Identification Marking
of U.S. Military Property

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MIL-STD-454

Standard General Requirements
for Electronic Equipment

MIL-STD-810

Environmental Test Methods

MS33543

Criteria - Temperature and
Altitude Range, Self Cooled
Electric Equipment

LSI/PED

Publications and Drawings

515270000

Outline, Generator
Control Unit

51527-100

Schematic and Inter-
connection Diagram

51527-250

System Interconnection
Diagram

51527-310

Printed Wiring Board Assy.
Voltage Regulator Circuit

51527-320

Printed Wiring Board Assy.
Logic Circuit

51527-330

Printed Wiring Board Assy.
Control Circuit

51527-340

Printed Wiring Board Assy.
Control Circuit

51527-300

Wiring Diagram

3.0

REQUIREMENTS

3.1

General:

The test and inspection defined herein demonstrate compliance of the 51527-000, Generator Control Unit, to the applicable requirements of Navy Specification No. NADC-60-TS-7803.

3.2

Test Equipment:

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The equipment listed in Tables 1 thru 3 are required to accomplish the test defined herein. Substitution, with equivalent or better items, is permitted.

3.2.1 Instrumentation:

Table 1, provides a list of the instruments and the accuracies needed for the measurements specified. Special go/no go indicators or circuits may be substituted for direct readings provided that evaluation accuracy is maintained.

3.2.1.1 Calibration:

All instruments shall be calibrated in accordance with the calibration requirements of MIL-C-45662.

3.2.2 Power Supplies:

Power supplies used in conjunction with the test of the unit shall have characteristic equal to or exceeding the list of Table 2.

3.2.3 External Loads:

Table 3 lists the external loads, that are connected during the testing of the GCU.

3.3 Test Conditions:

All acceptance tests shall be performed under the following conditions.

3.3.1 Environmental Conditions:

Temperature (ambient):	25° +/- 10°C (50°F to 104°F)
Atmospheric Pressure:	28 to 31 in. Hg.
Vibration:	None
Humidity:	Room ambient, up to 90% RH
Generator Speed:	16,000 +/- 600 RPM

3.3.2 Test Configuration:

The GCU shall be tested with its base down and horizontal and all connections shall be made thru the connectors or test points.

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Figure 2 illustrates the GCU without the top and bottom cover and the location of the adjustment potentiometers on the printed circuit boards.

3.4 Acceptance Test:

3.4.1 Examination of Product:

Each unit shall be examined for conformance with the drawing 51527000 with respect to weight, dimensions, materials, finishes, markings, proper parts, soldering and workmanship.

3.4.2 Dielectric Strength:

Remove the three printed wiring board assemblies and perform dielectric tests between chassis ground J1-7 & -53 and all other pins of J1 and J2 together as follows:

- a) With pins -13, 15, 16, 17, 18, 38, 40, 41, 43, 44, 46, 49, 50, 52, 55 tied together apply 1500 VAC for 1 minute.
- b) With the remaining pins of J1 and J2 tied together apply 500 VDC for 1 minute.

The leakage current shall not exceed 100 microamperes and there shall be no evidence of flashover (surface discharge) or breakdown (puncture).

3.4.3 Functional Tests:

The open loop functional test shall be performed first, followed by the closed-loop verification tests. Figure 1 shows the recommended test configuration for the GCU and also for the entire electrical system.

3.4.3.1 Open Loop Test:

Note: The test configuration of Figure 1 is recommended for open loop testing, using the PMG of the generator as power supply (PS No. 2). Also as an

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alternate equivalent to Sostel. the outputs at J2 connector can be tested with a 10 mA constant current supply.

3.4.3.1.1 Power Supplies:

With 350 VAC (L-L) 1200 Hz. power, applied between pins -52, -50 and -49 of connector J1 of the GCU measure the following voltages:

- +15.0 +/-1.0 VDC, between TP9-TP8 of PWB No. 1
- +26.5 +/-1.0 VDC, between TP1-TP8 of PWB No. 1
- +26.5 +/-1.0 VDC, between pins 28-17 of J1
- 27⁰.0 +/-10.0 VDC, between pins: 47-17 of PWB No. 1

3.4.3.1.2 Ripple Voltage Protection:

- a. With power supplied as in para. 3.4.3.1.1, connect an adjustable voltage and frequency single phase AC power source (PS No. 3) to switch 4 position 1. Monitor TP7 of PWB No. 3 and pin 1 of J2 (Sostel) connector.
- It* shall read 720 +/-150 Δ (or an equivalent 7.2 +/-1.5 VDC).

- b. Set the frequency to 4 KHz and increase the output voltage of the single phase power supply to read 12V (p-p). Adjust R312 until TP7 switches to "Lo" (0.0 + .5 VDC), and 6.0 +/-1 seconds later J2-1 reads 420 +/-50 Δ (or 4.2 +/-1.0 VDC). Return all switches to the configuration of Figure 1.

3.4.3.1.3 Failed (Open) Rectifier Detection:

- a. With power applied as in para. 3.4.3.1.1, connect the output of PS No. 3 to J1-13 (temporarily, disconnect the wiring to the generator, J1-2). Monitor TP6 of PWB No. 3 and pin 2 of J2 (Sostel).
- 3
- TP6 shall be in the "Hi" state and J2-3 shall read 720 +/-150 (or 7.2 +/-1.5 VDC).
- b. Set the frequency of PS No. 3 to 2 KHz and slowly increase the output voltage. When the peak-to-peak value exceeds 6.0

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volts TP8 shall switch to "Lo" state
(adjust R331 if required). 6.0 +/-1
seconds later the J2-3 shall read 420 +/-
50 Ω (or 4.2 +/- 1.0 VDC).

3.4.3.1.4 Failed (Shorted) Rectifier Detection:

- a. With condition of para. 3.4.3.1.3 maintained read J2-2. It shall read 720 +/-150 (or 7.2 +/-1.5 VDC).
- b. With a jumper lead short TP2 of PWB No. 1 to TP8, and observe the reading changing to 420 +/-50 Ω (or 4.2 +/-1.0 VDC) at J2-2. Return all switches to the configuration of Figure 1. Open all switches.

3.4.3.2 Closed-Loop Test (Single System)

3.4.3.2.1 Start-up and Shutdown operations

- a. Set the switches of Figure 1 in the following positions.

S1, S2 - Position 1
S3, S4 - Position 2
GCSw - "ON"

Connect the system (Generator, GCU, CS #1 & #2, LC and BTC) as shown on Figure 1. The constant current monitoring system (Sostel) shall give the following indications between pin J2-9 (GND) and the following pins of J2 of the GCU:

J2-1	-	720 Ω +/-150	or	7.2 +/-1.5 VDC
J2-2	-	720 Ω +/-150	or	7.2 +/-1.5 VDC
J2-3	-	720 Ω +/-150	or	7.2 +/-1.5 VDC
J2-4	-	720 Ω +/-150	or	7.2 +/-1.5 VDC
J2-5	-	720 Ω +/-150	or	7.2 +/-1.5 VDC
J2-6	-	720 Ω +/-150	or	7.2 +/-1.5 VDC
J2-7	-	720 Ω +/-150	or	7.2 +/-1.5 VDC
J2-8	-	720 Ω +/-150	or	7.2 +/-1.5 VDC
J2-10	-	1100 Ω +/-200	or	11.0 +/-2.0 VDC
J2-11	-	1100 Ω +/-200	or	11.0 +/-2.0 VDC

- b. With an oscilloscope monitor TP4 of PWB

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No. 3, while starting the generator drive. Initially the voltage at the monitor point will slowly increase in proportion to the speed of the generator, then reaches a constant value of 14 +/-1.0 VDC ("Hi" state). L1 and L2 indicator lights shall be ON. When the generator speed reaches 8000 +/-600 RPM, the Generator output voltage shall read 270 +/-5 VDC (adjust R100 for voltage and R334 for ~~if required~~ *SPEED*). Indicator lights L1 & L2 shall be OFF, and TP4 of PWB No. 3 shall switch to the "Lo" state. The generator load current indicator shall show the 5 amps pre-load.

- c. Set the Generator speed to 9,000 +/- 50 RPM and apply .5, 1.0 and 1.25 PU (167 amp) load current. The voltmeter at the POR shall have +/-5 volts regulation limits (from no load setting of step b) for all loads, except for 1.25PU, where it shall be 270 +/-10 volts.
- d. Increase the generator speed to 18,000 RPM and repeat step c).
- e. Reduce speed to 16,000 RPM and repeat step C.
- f. Using the constant current source and the monitoring system read the status of J2 signals. They shall read as follows:

J2-1	-	720 +/-150 Ω	or	7.2 +/-1.5 VDC
J2-2	-	720 +/-150 Ω	or	7.2 +/-1.5 VDC
J2-3	-	720 +/-150 Ω	or	7.2 +/-1.5 VDC
J2-4	-	720 +/-150 Ω	or	7.2 +/-1.5 VDC
J2-5	-	720 +/-150 Ω	or	7.2 +/-1.5 VDC
J2-6	-	720 +/-150 Ω	or	7.2 +/-1.5 VDC
J2-7	-	720 +/-150 Ω	or	7.2 +/-1.5 VDC
J2-8	-	720 +/-150 Ω	or	7.2 +/-1.5 VDC
J2-10	-	720 +/-150 Ω	or	7.2 +/-1.5 VDC
J2-11	-	720 +/-150 Ω	or	7.2 +/-1.5 VDC

- g. Move the GCSw to OFF (middle) position. L1 L2 shall go ON, POR voltage drops to zero and J2-11 shall read $420 \pm 50\Omega$ (or 4.2 ± 1.0 VDC).
- h. Move the GCSw to test position. The POR voltage shall read 270 ± 10 VDC, L1 and L2 remain unchanged.
- i. Move the GCSw back to OFF and to ON position. L1 and L2 shall be OFF and J2 status pins read as in step f.
- j. Monitor TP1 and TP4 of PWB No. 3 while reducing the speed of the generator. When the generator speed drops below 8000 ± 500 RPM, TP4 switches into the "Hi" state. (Adjust R334 if required) 2-3 seconds later TP1 switches "Lo", both indicator lights (L1, L2) shall go ON and the POR voltage drops to zero. J2-11 shall read $420 \pm 50\Omega$.

3.4.3.2.2 Overvoltage Protection Test:

- a. With the system operating at $16,000 \pm 100$ RPM, adjust R100 of PWB No. 1 to increase the regulated output voltage of the generator. Monitor TP3 of PWB No. 1 and J2-3 of the Sostel output connector. TP3 shall be in the "Lo" state and J2-3 shall read $720 \pm 150\Omega$ (or 7.2 ± 1.5 VDC). L1 and L2 are ON.
- b. When the output voltage of 290 VDC is reached TP3 switches momentarily to "Hi" (Adjust R101 if required). The generator is de-energized, L1 & L2 shall go ON and J2-3 shall read $420 \pm 50\Omega$ (or 4.2 ± 1.0 VDC).
- c. Move the GCSw to OFF and back to ON position. There shall be no change in the status (J2) and indicator lights conditions.
- d. Readjust R100 to step a) condition and

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move the GCSw to OFF and back to ON position. L1 & L2 shall go OFF and J2-3 shall read again as in step a).

3.4.3.2.3 Undervoltage Protection Test:

- a. With the system operating at 16,000 +/- 100 RPM, adjust R100 of PWB No. 1 to decrease the regulated output of the generator. Monitor J2-7 and J2-11. They shall read 720 +/-150 Ω (or 7.2 +/-1.5 VDC). L1 & L2 shall be OFF.
- b. After the POR voltage of 245 +/-5 VDC is reached the generator is de-energized, (Adjust R306 if required) L1 & L2 go ON and J2-7 and J2-11 read 420 +/-50 Ω (or 4.2 +/-1.0 VDC).
- c. Move the GCSW to OFF and back to ON position. The generator shall build-up to the set level but 5-7 seconds later shall de-energized again. L1 & L2 and J2-7 status remain unchanged.
- d. Readjust R100 to step a) condition and repeat the reset test of step c). The generator shall build-up to 270 +/-5 VDC. L1 & L2 shall be OFF and J2-7 and J2-11 shall read the same as in step a).

3.4.3.2.4 Feeder Fault Protection Test:

- a. With the system operating at 16,000 +/-100 RPM, monitor TP5 of PWB No. 3 and pins -5 and -11 of the Sostel connector (J2). TP5 shall be in the "H1" state and J2-5 and 11 shall read 720 +/-150 Ω (or 7.2 +/-1.5 VDC). L1 & L2 shall be OFF.
- b. Apply a fault current of 63 +/-5 amps between the protective zone of CS #1 and CS #2. (Generator terminal to line contactor) while monitoring TP5 of PWB No. 3 and the respective Sostel outputs (J2-5 and J2-11).

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Less than 50 milliseconds after a fault application TP5 switches to "Lo" state. L1 & L2 shall go ON and J2-5 and J2-11 shall read 420 +/-50Ω (or 4.2 +/-1.0 VDC).

- c. Attempt a GCSw reset with the fault still applied between the protective zone. There shall be no change in the indicator light or the Sostel output monitor status.
- d. Remove the fault and repeat reset action. The generator shall energize, L1 & L2 shall be OFF and J2-5 and J2-11 shall read the values recorded in step a).

3.4.3.2.5

Overcurrent Protection Test

- a. With the system operating at 16,000 +/-100 RPM. Apply 1.0 PU (167 amps) to the generator. Monitor the POR voltage and J2-6 of Sostel. The voltage shall be 270 +/-5 VDC and J2-6 shall read 720 +/-150Ω (or 7.2 +/-1.5 VDC). L1 & L2 shall be OFF.
- b. Increase the load current to greater than 250 amps. Attempt to further increase the load current will result in decrease of the POR voltage while the load current remains essentially the same. Seven seconds after the application of the overload the generator will be de-energized. L1 & L2 shall go ON and J2-6 and J2-11 shall read 420 +/-50Ω (or 4.2 +/-1.0 VDC).
- c. Remove the overload and return the system to the normal operating conditions of step a).

3.4.3.2.6

Generator Warning and Disconnect Test:

NOTE: Generator Disconnect testing is done during qualification testing, therefore, only simulated test shall be performed here, using the power resistor R1

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as the disconnect coil.

- a. With the system operating at 16,000 \pm 100 RPM, read the status of pins -10 and -11 of Sostel connector J2. They shall read 720 \pm 150 Ω (or 7.2 \pm 1.5 VDC) and L1 & L2 shall be OFF. With a scope monitor R1 voltage. It shall indicate a "Lo" state.
- b. Momentarily ground pin 12 of J1 connector. 200 \pm 50 milliseconds after application, the scope shall switch to "Hi" (270 volts) state, the generator shall be de-energized (L1 & L2 ON) and J2-10 shall read 1100 \pm 200 Ω (or 11.0 \pm 2.0 VDC) and J2-11 shall read 420 \pm 50 Ω (or 4.2 \pm 1.0 VDC).
- c. Remove the short (ground) from J1-12 of the GCU and reset the system by moving momentarily the GCSw to OFF and back to ON position. All indication and readings shall be the same as in step a).
- d. Open wire J1-10 at the GCU and read the generator status indicator J2-10. It shall read 1100 \pm 200 Ω (or 11.0 \pm 2.0 VDC). All other indications remain normal.

At this point, the GCU has completed the requirement for control and protection of a single high voltage electrical system.

4. QUALITY ASSURANCE PROVISIONS

- 4.1 The Quality Control Department shall establish the necessary procedures and controls to assure conformance with the requirements of this specification with regard to test methods, test equipment, instrumentation and failure reporting.

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4.2

Test Records:

Certified test reports shall be prepared for each unit successfully completing the Acceptance Test. One copy of the test report shall be retained on file by the Quality Control Department and a copy shall accompany each unit that is delivered.

4.2.1

Data Sheet:

The test report shall be prepared on a data sheet that shall contain, as a minimum, the following information.

- a. Unit model number and nomenclature
- b. Test specification number and revision level
- c. Unit serial number
- d. Adequate test records shall be prepared for each unit subjected to the acceptance tests herein, recording pertinent data as required in the detail tests
- e. Weight

4.3

Rejection, Retest, and Failure Reporting

4.3.1

Rejection and Retests:

Units that are rejected during Acceptance Testing may be reworked or have parts replaced to correct the defect and then may be resubmitted for Acceptance Test.

4.3.2

Failure Reporting:

In cases of requirement, the Quality Control Department shall report each failure occurring during Acceptance Testing in accordance with specification 99-520000. A copy of this report shall be submitted to LSI/PED Reliability.

4.3.3

Disposition of Failed Parts:

Failed parts shall be appropriately

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identified and retained until a failure analysis has been performed by Quality Control and/or Reliability Engineering.

5. Definitions, Tables, and Figures.

5.1 Definitions and Abbreviations

5.1.1 Definitions

5.1.1.1 Point of Regulation:

The point at which the regulator senses and establishes system voltage for Acceptance Test purposes.

5.1.1.2 Rating:

System rating shall be 45KW, based on 270V volts at the generator terminal.

Abbreviations

GCU - Generator Control Unit
VAC - Volts Alternating Current
VDC - Volts Direct Current
Hz - Hertz
I - Point of Regulation
GCSw - Generator Control Switch
CSA - Current Sensor Assembly
PWB - Printed Wiring Board
PS - Power Supply

5.2 Tables

5.2.1 Table 1 Instrument List
5.2.2 Table 2 Power Supply List
5.2.3 Table 3 External Load List

5.3 Figures

5.3.1 Figure 1 HVDC Electrical System
5.3.2 Figure 2 Generator Control Unit

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Table I
Instrument List

<u>Function</u>	<u>Range Required</u>	<u>Accuracy % of Range</u>	<u>Notes</u>
Dielectric Voltage	15000 VAC 0-1000 ua	3% 3%	60 Hz
Continuity	0-.2 ohm	2%	4.5 VDC max
Resistance	5-600 ohm	0.1% of reading	
AC Voltage	0-1999 VAC +/- .15% of reading	+/-1 digit scale	
DC Voltage	0-300 VDC	.5% full scale	
Oscilloscope	.1-10u sec/div 50/10 mv/div	3% 3%	For ripple, waveform and time measure- ment
Events of Unit Time Counter	300-15000 cycles	+/-1.1 counts	Frequency (speed) and time measure- ments
DC Current	0-500 amps	1% of range	

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Table 3
Special Load List

<u>Load Designations</u>	<u>Description</u>	<u>Value</u>	<u>Wattage</u>	<u>Notes</u>
R1	Fixed Resistor	2.7K	50W	Figure 1
R2	Fixed Resistor	550 Ω	150W	Figure 1
L1, L2	Indicator Lights	28.0V	1/4W	Figure 1

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Table 2
Power Supply List

<u>Source Designation</u>	<u>Source Type</u>	<u>Required value or range</u>	<u>Accuracy</u>	<u>Load</u>	<u>Notes</u>
PS No. 1	Voltage DC	0-400 VDC	+/- .1 VDC	.5 amps	Figure 1
PS No. 2	3 AC	0-300 VAC (L-L)	+/-10 VAC	2.0 amps	Figure 1
PS No. 3	Voltage AC	0-30 VAC	+/-1.0 VDC	1.0 amps	Figure 1
PS No. 4	Voltage DC	0-50 VDC	+/- .1 VDC	.5 VDC	Figure 1
PS No. 5	Current, Constant	0-10 mA	+/-1.0 mA	Variable	Figure 1

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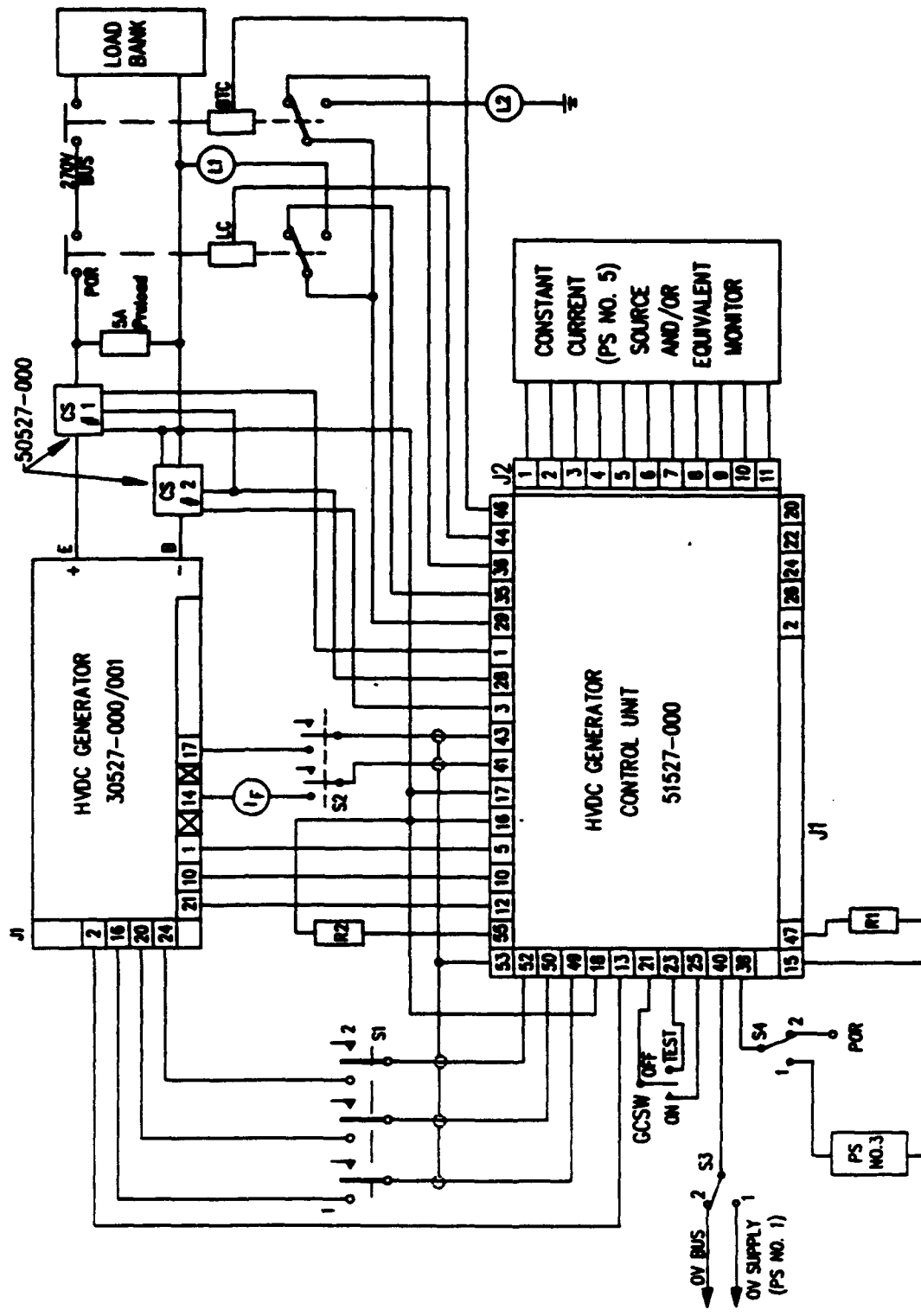


Figure 1 HVDC Electrical System

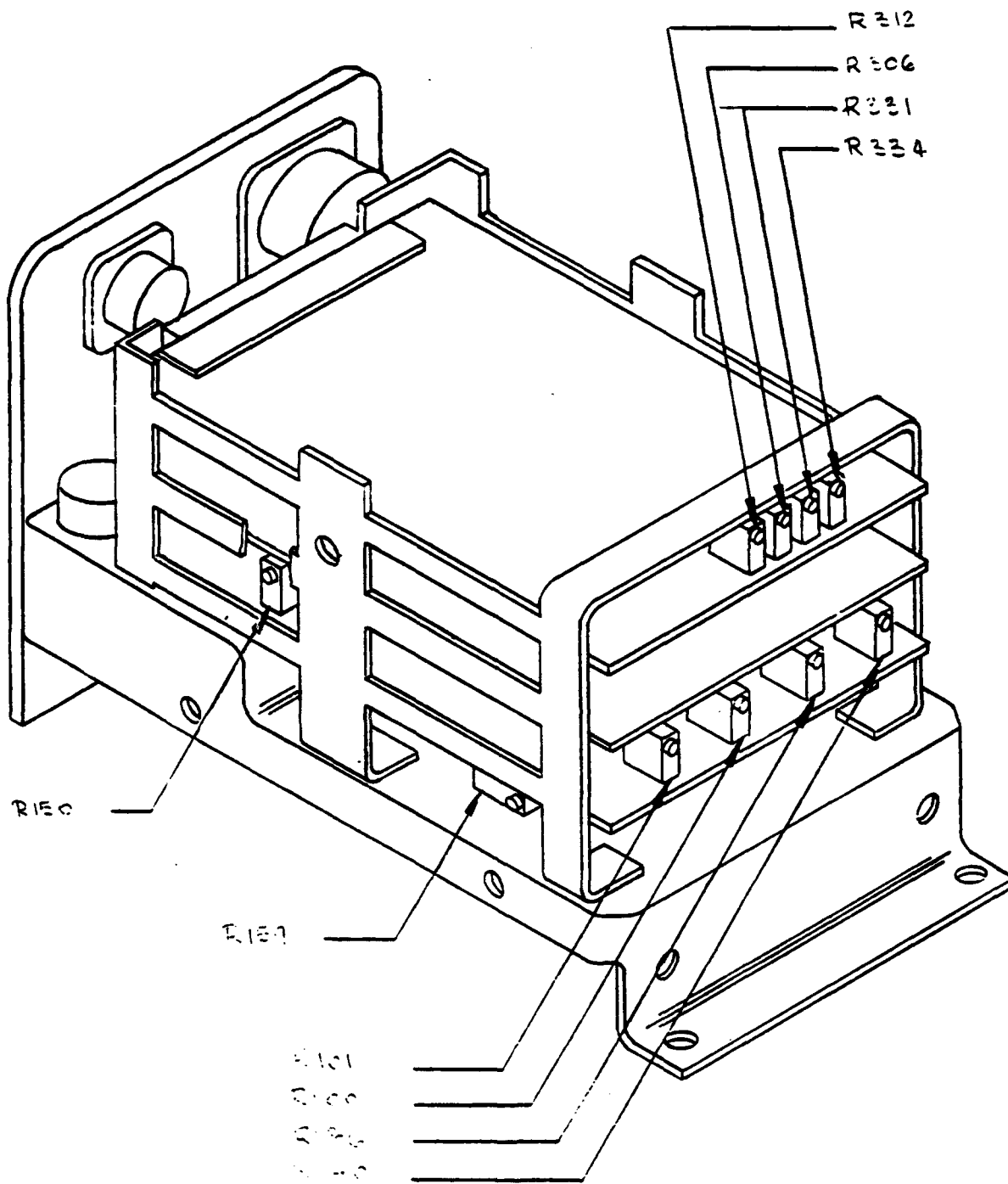


FIGURE 1. POWER SUPPLY UNIT (PSU) - FRONT VIEW

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FORM 1340 8/5 (12/02)

EXPERIMENTAL LABORATORY TEST RECORD

E.W.O. 54805 MODEL NO. 51527-000 SERIAL NO. 103 COG. ENGR. Harriet ROTOR NO. STATOR NO.

DATE OF TEST 5/26/88 TEST LETTER: NO. QP 387 TESTED BY R. J. SAKUR

BRUSH GRADE BAR. PRESSURE M.P. AIR GAP I.P. AIR GAP

TITLE				ACCEPTANCE TEST PROCEDURE				17-510121				PAGE 1 OF 9			
PARAM. NO.		TIME		A.M.S. TEMP.											
3431						OPEN AMP									
4.3.1.1						POWER SUPPLIES									
						350 VAC (440 Hz) IN									
		A				TP9 = 15.03 V									
		B				TP1 = 22.37									
		C				PN 28 = 22.39									
		D				PN 47 = 31.5 V									
4.3.1.2						RIPPLE VOLTAGE PROTECTION									
		A				TP7-PUB3 = "H1" 14.95 V PW 1 OF J2 = 2.7 V									
		B				TP7-PUB3 = "LOW" 00.90 V PW 1 OF J2 = 5.1 V									
						TIME IN SEC = 5.5 SEC									
4.3.1.3						FAILED (OPEN) RECTIFIER DETECTION									
		A				TP6-PUB3 = "H1" 14.95 V									
						J2-8 = 7.7 V									
		B				TP6-PUB3 = "LOW" 0.9 V									
						J2-8 = 2.5 V									

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COG. ENGR. HARRIS

EXPERIMENTAL LABORATORY TEST RECORD

MODEL NO. 51527-000 SERIAL NO. 103

ROTOR NO. _____

STATOR NO. _____

E.W.O. 54805

DATE OF TEST _____

TEST LETTER: NO. QP 887

TESTED BY R. J. SARKIS

BRUSH GRADE _____

BAR. PRESSURE _____

M.P. AIR GAP _____

I.P. AIR GAP _____

TITLE: <u>ACCEPTANCE TEST PROCEDURE</u>		<u>17-510121</u>		PAGE <u>2</u> OF <u>9</u>	
PARA. NO.	TIME	AMM. TEMP.			
<u>13.1.1</u>			<u>Failed (Shorted) Rectifier DETECTION</u>		
<u>A.</u>					
			<u>J2-3 = 7.7 V</u>		
			<u>J2-2 = 5.1 V</u>		
<u>13.2.0</u>			<u>Closed Loop (Control system)</u>		
<u>13.2.1</u>			<u>Start-up and Shut Down operations</u>		
<u>A.</u>					
			<u>J2-1 = 7.7 V</u>		
			<u>J2-2 = 7.7 V</u>		
			<u>J2-3 = 7.7 V</u>		
			<u>J2-4 = 7.7 V</u>		
			<u>J2-5 = 7.7 V</u>		
			<u>J2-6 = 7.7 V</u>		
			<u>J2-7 = 7.7 V</u>		
			<u>J2-8 = 7.7 V</u>		
			<u>J2-10 = 11.7 V</u>		
			<u>J2-11 = 11.7 V</u>		

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ROTOR NO. STATOR NO.

TESTED BY R. J. SAVICK

I.P. AIR GAP

PAGE 3 OF 9

TIME	WIND DIR	WIND SPEED
------	-------------	---------------

START UP	AND SHOT DOWN	OPERATIONS
----------	---------------	------------

TP4-PUB3	"A"	"B"	"C"	"D"	"E"	"F"	"G"	"H"	"I"	"J"	"K"	"L"	"M"	"N"	"O"	"P"	"Q"	"R"	"S"	"T"	"U"	"V"	"W"	"X"	"Y"	"Z"	"AA"	"AB"	"AC"	"AD"	"AE"	"AF"	"AG"	"AH"	"AI"	"AJ"	"AK"	"AL"	"AM"	"AN"	"AO"	"AP"	"AQ"	"AR"	"AS"	"AT"	"AU"	"AV"	"AW"	"AX"	"AY"	"AZ"	"BA"	"BB"	"BC"	"BD"	"BE"	"BF"	"BG"	"BH"	"BI"	"BJ"	"BK"	"BL"	"BM"	"BN"	"BO"	"BP"	"BQ"	"BR"	"BS"	"BT"	"BU"	"BV"	"BW"	"BX"	"BY"	"BZ"	"CA"	"CB"	"CC"	"CD"	"CE"	"CF"	"CG"	"CH"	"CI"	"CJ"	"CK"	"CL"	"CM"	"CN"	"CO"	"CP"	"CQ"	"CR"	"CS"	"CT"	"CU"	"CV"	"CW"	"CX"	"CY"	"CZ"	"DA"	"DB"	"DC"	"DD"	"DE"	"DF"	"DG"	"DH"	"DI"	"DJ"	"DK"	"DL"	"DM"	"DN"	"DO"	"DP"	"DQ"	"DR"	"DS"	"DT"	"DU"	"DV"	"DW"	"DX"	"DY"	"DZ"	"EA"	"EB"	"EC"	"ED"	"EE"	"EF"	"EG"	"EH"	"EI"	"EJ"	"EK"	"EL"	"EM"	"EN"	"EO"	"EP"	"EQ"	"ER"	"ES"	"ET"	"EU"	"EV"	"EW"	"EX"	"EY"	"EZ"	"FA"	"FB"	"FC"	"FD"	"FE"	"FF"	"FG"	"FH"	"FI"	"FJ"	"FK"	"FL"	"FM"	"FN"	"FO"	"FP"	"FQ"	"FR"	"FS"	"FT"	"FU"	"FV"	"FW"	"FX"	"FY"	"FZ"	"GA"	"GB"	"GC"	"GD"	"GE"	"GF"	"GG"	"GH"	"GI"	"GJ"	"GK"	"GL"	"GM"	"GN"	"GO"	"GP"	"GQ"	"GR"	"GS"	"GT"	"GU"	"GV"	"GW"	"GX"	"GY"	"GZ"	"HA"	"HB"	"HC"	"HD"	"HE"	"HF"	"HG"	"HH"	"HI"	"HJ"	"HK"	"HL"	"HM"	"HN"	"HO"	"HP"	"HQ"	"HR"	"HS"	"HT"	"HU"	"HV"	"HW"	"HX"	"HY"	"HZ"	"IA"	"IB"	"IC"	"ID"	"IE"	"IF"	"IG"	"IH"	"II"	"IJ"	"IK"	"IL"	"IM"	"IN"	"IO"	"IP"	"IQ"	"IR"	"IS"	"IT"	"IU"	"IV"	"IW"	"IX"	"IY"	"IZ"	"JA"	"JB"	"JC"	"JD"	"JE"	"JF"	"JG"	"JH"	"JI"	"JJ"	"JK"	"JL"	"JM"	"JN"	"JO"	"JP"	"JQ"	"JR"	"JS"	"JT"	"JU"	"JV"	"JW"	"JX"	"JY"	"JZ"	"KA"	"KB"	"KC"	"KD"	"KE"	"KF"	"KG"	"KH"	"KI"	"KJ"	"KK"	"KL"	"KM"	"KN"	"KO"	"KP"	"KQ"	"KR"	"KS"	"KT"	"KU"	"KV"	"KW"	"KX"	"KY"	"KZ"	"LA"	"LB"	"LC"	"LD"	"LE"	"LF"	"LG"	"LH"	"LI"	"LJ"	"LK"	"LL"	"LM"	"LN"	"LO"	"LP"	"LQ"	"LR"	"LS"	"LT"	"LU"	"LV"	"LW"	"LX"	"LY"	"LZ"	"MA"	"MB"	"MC"	"MD"	"ME"	"MF"	"MG"	"MH"	"MI"	"MJ"	"MK"	"ML"	"MM"	"MN"	"MO"	"MP"	"MQ"	"MR"	"MS"	"MT"	"MU"	"MV"	"MW"	"MX"	"MY"	"MZ"	"NA"	"NB"	"NC"	"ND"	"NE"	"NF"	"NG"	"NH"	"NI"	"NJ"	"NK"	"NL"	"NM"	"NN"	"NO"	"NP"	"NQ"	"NR"	"NS"	"NT"	"NU"	"NV"	"NW"	"NX"	"NY"	"NZ"	"OA"	"OB"	"OC"	"OD"	"OE"	"OF"	"OG"	"OH"	"OI"	"OJ"	"OK"	"OL"	"OM"	"ON"	"OO"	"OP"	"OQ"	"OR"	"OS"	"OT"	"OU"	"OV"	"OW"	"OX"	"OY"	"OZ"	"PA"	"PB"	"PC"	"PD"	"PE"	"PF"	"PG"	"PH"	"PI"	"PJ"	"PK"	"PL"	"PM"	"PN"	"PO"	"PP"	"PQ"	"PR"	"PS"	"PT"	"PU"	"PV"	"PW"	"PX"	"PY"	"PZ"	"QA"	"QB"	"QC"	"QD"	"QE"	"QF"	"QG"	"QH"	"QI"	"QJ"	"QK"	"QL"	"QM"	"QN"	"QO"	"QP"	"QQ"	"QR"	"QS"	"QT"	"QU"	"QV"	"QW"	"QX"	"QY"	"QZ"	"RA"	"RB"	"RC"	"RD"	"RE"	"RF"	"RG"	"RH"	"RI"	"RJ"	"RK"	"RL"	"RM"	"RN"	"RO"	"RP"	"RQ"	"RR"	"RS"	"RT"	"RU"	"RV"	"RW"	"RX"	"RY"	"RZ"	"SA"	"SB"	"SC"	"SD"	"SE"	"SF"	"SG"	"SH"	"SI"	"SJ"	"SK"	"SL"	"SM"	"SN"	"SO"	"SP"	"SQ"	"SR"	"SS"	"ST"	"SU"	"SV"	"SW"	"SX"	"SY"	"SZ"	"TA"	"TB"	"TC"	"TD"	"TE"	"TF"	"TG"	"TH"	"TI"	"TJ"	"TK"	"TL"	"TM"	"TN"	"TO"	"TP"	"TQ"	"TR"	"TS"	"TT"	"TU"	"TV"	"TW"	"TX"	"TY"	"TZ"	"UA"	"UB"	"UC"	"UD"	"UE"	"UF"	"UG"	"UH"	"UI"	"UJ"	"UK"	"UL"	"UM"	"UN"	"UO"	"UP"	"UQ"	"UR"	"US"	"UT"	"UU"	"UV"	"UW"	"UX"	"UY"	"UZ"	"VA"
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[illegible][illegible]

INDICATOR LIGHTS	OFF	22
	ON	22

P.O.R. = 27085V 15702 10/11/1945 PKE-LoAD

[illegible]

9000 Rm 2723 V 5 Am 4 PRE-LOAD

2205 R24 26.1 / 27 Aug 2017

9016 Cmc	267.3	✓	147 days	4.40
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9000 RPM = 264.3 V 208 gmc 4000

[illegible]

7650 RPM	266.3 V	24 mag	1.640
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16744	16744	16744
16745	16745	16745
16746	16746	16746
16747	16747	16747
16748	16748	16748
16749	16749	16749
16750	16750	16750
16751	16751	16751
16752	16752	16752
16753	16753	16753
16754	16754	16754
16755	16755	16755
16756	16756	16756
16757	16757	16757
16758	16758	16758
16759	16759	16759
16760	16760	16760
16761	16761	16761
16762	16762	16762
16763	16763	16763
16764	16764	16764
16765	16765	16765
16766	16766	16766
16767	16767	16767
16768	16768	16768
16769	16769	16769
16770	16770	16770
16771	16771	16771
16772	16772	16772
16773	16773	16773
16774	16774	16774
16775	16775	16775
16776	16776	16776
16777	16777	16777
16778	16778	16778
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16780	16780	16780
16781	16781	16781
16782	16782	16782
16783	16783	16783
16784	16784	16784
16785	16785	16785
16786	16786	16786
16787	16787	16787
16788	16788	16788
16789	16789	16789
16790	16790	16790
16791	16791	16791
16792	16792	16792
16793	16793	16793
16794	16794	16794
16795	16795	16795
16796	16796	16796
16797	16797	16797
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16799	16799	16799
16800	16800	16800
16801	16801	16801
16802	16802	16802
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16807	16807	16807
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16810	16810	16810
16811	16811	16811
16812	16812	16812
16813	16813	16813
16814	16814	16814
16815	16815	16815
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16828	16828	16828
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16831	16831	16831
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16834	16834	16834
16835	16835	16835
16836	16836	16836
16837	16837	16837
16838	16838	16838
16839	16839	16839
16840	16840	16840
16841	16841	16841
16842	16842	16842
16843	16843	16843
16844	16844	16844
16845	16845	16845
16846		

[illegible][illegible][illegible][illegible]

60066 PPM 26.1.1 ✓ 167 SHP SWAP

6000 kg / 210 kg / 2025

[illegible][illegible][illegible]

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PRECEDING PAGE NO	FOLLOWING PAGE NO

NO. 19934

UNIVERSITY OF TORONTO

EW.O. 54,805

MODEL NO. 51527-000

EXPERIMENTAL LABORATORY TEST RECORD

COG. ENGR.

SERIAL NO. 103

STATOR NO.

DATE OF TEST

5726/88

TEST LETTER: NO. PP 387

TESTED BY R. J. Sams

BRUSH GRADE

BAR. PRESSURE

M.P. AIR GAP

1P AIR GAP

TIME:

ACCEPTANCE TEST PROCEDURE 17-510/21

PAGE 5 of 9

PAGE.

AMS.

AMS.

4.3.2

START-UP AND SHUT-DOWN OPERATIONS

七

TPY-PUBB	"H" STATE	normal cooperation
----------	-----------	--------------------

TPV-PW03	Low state
----------	-----------

GENERATOR SPIN BELOW 8000 RPM

TP4-P2B3	5402 TC 4/85	41	5 TA 7E
----------	--------------	----	---------

2. 25

TP1-PWB-3	13w17HES	Td	60	STA TR
-----------	----------	----	----	--------

41765 ARE "ON"	P.O.R. DISTANCE	"O"
----------------	-----------------	-----

OVERVOLTAGE	PROTECTIVE TEST
-------------	-----------------

ॐ

1600Rpx.	84Apx	866	V
----------	-------	-----	---

03	04081	" 604	" 57275
----	-------	-------	---------

2-8	27	✓
-----	----	---

1000

8

OUTPUT	RAISED TO 290VDC
--------	------------------

723 RWB 1
SHUTTLES
H. H. MINEART & SONS

GENERATOR	DE-ENERGIZED
-----------	--------------

7	137	"10"
---	-----	------

12-3	5,1	V
------	-----	---

E.W.O. 5081.5

MODEL NO. 51527-000 SERIAL NO. 103

EXPERIMENTAL LABORATORY TEST RECORD

COG. ENGR. HARMAI

SERIAL NO. 103

ROTOR NO. STATOR NO.

DATE OF TEST

5/27/88 TEST LETTER: NO. QP 387 TESTED BY R. J. SANILUK

2

BRUSH GRADE

BAR. PRESSURE

M.P. AIR GAP

I.P. AIR GAP

Time:

TIME: ACCEPTANCE TEST PROCEDURE 17-510121

PAGE 16 OF 92

34327

OVERVOLTAGE PROTECTION TEST

ש

No	CHANGE	(SAME AS B)
----	--------	-------------

Q

Normal operation
Lites "off"

J2-3

27 ✓

Y3.23

UNDERVOLTAGE	PROTECTION	TEST
--------------	------------	------

4

1600 RPS	84 APR	266	✓
----------	--------	-----	---

22-7 = 77 v

72-11-80	V
----------	---

8

POOR	VOLTAGE	DECREASED	TO 2 V3 V
------	---------	-----------	-----------

12-7-51 ✓

12.11.51	V
----------	---

1.75	" 31 "
------	--------

(GENERATOR DE-ENERGIZED)

2

GCSW SWITCH FROM	ON	To "OFF"	To "ON"
------------------	----	----------	---------

GEAR-TECH

GENERATOR S FARRER (206 V)

L1705 ACE ONLY

LILAS ARE ONLY

IT-7 AND 11 SAME AS "B"

17-7	11	SAME AS "B"
------	----	-------------

FORM 1249 8/3 11/2/62	PRECEDING PAGE NO
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FOLLOWING

700

EXPERIMENTAL LABORATORY TEST RECORD

COG. ENGR. HARMA

ROTOR NO. _____

S.W.O. 54805MODEL NO. 51527-000 SERIAL NO. 163

DATE OF TEST

5/27/88TEST LETTER: NO. QR387TESTED BY R. J. SAVINAK

BRUSH GRADE _____

BAR. PRESSURE _____

M.P. AIR GAP _____

I.P. AIR GAP _____

TITLE:

Acceptance Test Procedure 17-510121

PARA. NO.

TIME

A.M.

TEMP.

PAGE 7 OF 9

4323UNDER VOLTAGE PROTECTION TESTD.PAR ADJUSTED TO 267.9VNORMAL OPERATIONLITES "OFF"J2-7 AND 11 SAME AS STEP "A"4324FEEDER FAULT PROTECTION TESTA.1600 RPM 84 AMPS 267.9VTP5-PW03 = "Hi." STATEJ2-5 = V 27VJ2-11 = V 82VLITES ARE "OFF"B.A 43.5 AMP FAULT IS APPLIED TO SYSTEMSYSTEMTP5-PW03 = "Lo" STATEJ2-5 61VJ2-11 61VLITES ARE "ON"

EXPERIMENTAL LABORATORY TEST RECORD

E.W.O. 54805

MODEL NO. 5/S27-000 SERIAL NO. 104

ROTOR NO. STATOR NO.

STATOR NO.

DATE OF TEST

5-27/88 TEST LETTER: NO. DP 387 TESTED BY R.J. SANLIK

BRUSH! GRADE

BAR. PRESSURE

M.P. AIR GAP

I.P. AIR GAP

DATE: 17-5/10/21 PAGE 8 OF 9

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PAR. NO.	TIME	AMP. (RMS)
4324		
C		
UNDER VOLTAGE PROTECTION TEST		
SYSTEM WILL NOT RESET W/IN FAULT LINES "ON"		
T2-5 AND 11 SAME AS STEP B (NO CHANGE)		
D		
FAULT REMOVED AND SYSTEM RESET		
OPERATION -		
LINES "OFF"		
T2-5 AND 11 SAME AS STEP A		
4325		
A		
OVER CURRENT PROTECTION TEST		
KOHPP 167A, 2680 V		
T2-6 = 3.7 V T2-11 = 8.2 V		
PDR 2670 VDC		
LINES ARE "OFF"		
B		
LOAD INCREASE TO GREATER THAN 250A AND APPLIED		
260 A FOR 7 SECONDS, GENERATOR DE-ENERGIZED		
LINES "ON"		
T2-6 AND 11 = 5.1 V		
C		
OVERLOAD REMOVED, RESET NORMAL OPERATION		

FORM 1349 2/5 (12/62) PRECEDING PAGE NO. —

FOLLOWING
PAGE NO.

AF SIG

NO. 19939

266A
18.12.1

POWER EQUIPMENT DRP

EXPERIMENTAL LABORATORY TEST RECORD

W.O. 54805 MODEL NO. 67527-000 SERIAL NO. 103 COG. ENGR. *WARR* ROTOR NO. STATOR NO.

DATE OF TEST 5/22/88 TEST LETTER: NO. QP 387 TESTED BY R. J. SANLUK

IRUSH GRADE BAR. PRESSURE M.P. AIR GAP I.P. AIR GAP

TITLE: ACCEPTANCE TEST PROCEDURE 17-510131				PAGE 9 of 9	
TIME	PARA. NO.	AMB. TEMP.			
1320			GENERATOR WARMING AND DISCONNECT TEST		
			SIMULATED TEST POWER RESISTOR USED IN PLACE OF DISC COIL		
A			16000 RPM, 269 VDC		
			J2-10 = 8.2 V		
			J2-11 = 8.2 V		
			LITES ARE "OFF"		
			RES VOLTAGE "LOW" STATE		
B			PIN 12 J1 SHORTED TO GND (PIN 12 OF U210)		
			RES VOLTAGE "HI" STATE		
			J2-10 = 11.5 V		
			J2-11 = 5.1 V		
			LITES ARE "ON"		
C			REMOVE SHORTEN PIN 12 J1		
			RESET SYSTEM OPERATION NORMAL		
D			OPEN J1 PIN 10		
			J2-10 11.5 V		
			OTHER INDICATIONS NORMAL		

w.o. 54805

EXPERIMENTAL LABORATORY. TEST RECORD

COG. ENGR. HARRIS

W.O. 54805

MODEL NO. 51527-000

SERIAL NO. 104

STATOR NO.

DATE OF TEST

88/11/9

TEST LETTER: NO. 09387

TESTED BY R. J. SANKUK

RUSH GRADE

BAR. PRESSURE

M.P. AIR GAP

I.P. AIR GAP

FILE: ACCEPTANCE TEST PROCEDURE 17-510121

PAGE 7 OF 9

[illegible]

431	OPEN LOOP
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13.1.1	POWER	SUPPLIES
--------	-------	----------

350 VAC (L-L) 1200 Hz 1A.

A TP2 = 14.26

B	TP1	= 26.91
---	-----	---------

2	和 28	= 26.92
---	------	---------

↓ $p_{12} = 28\%$

13.1.2 Ripple Voltage Protection

A	TPD-PWB3	$H_i = 14.774$	PIN 10F	$J_2 =$	2.7K
---	----------	----------------	---------	---------	------

B	TP2-PV83	Low + 0.01 V	PW	of J2 =	4.9 V
---	----------	--------------	----	---------	-------

Time ~~5~~ 5 sec 5 sec

1/3/13	FAILEN (OPERA) REFLECTER DETECTION
--------	------------------------------------

4	4	706-plw83-	H1	• 14780
---	---	------------	----	---------

J2-8

B. $TP6 - PW8.3 = \angle PW = 99.5$

J2+8	5.05V.
------	--------

EXPERIMENTAL LABORATORY TEST RECORD

COG. ENGR. HARMA

ROTOR NO. STATOR NO.

MODEL NO. 51527-000

W.O. 54805

DATE OF TEST 6/11/88 TEST LETTER: NO. QP 387 TESTED BY R. J. SANIUK

TEST LETTER: NO. QP 387

88/11/88

DATE OF TEST _____

BRUSH GRADE

BAR. PRESSURE

M P. AIR GAP

I.P. AIR GAP

FILE: ACCEPTANCE TEST PROCEDURE 17-510131

PAGE 3 OF 9

PAGE NO.	TIME	AMB. TEMP.	TESTING
13.14			Failure (SHORTED) RECTIFIER DETECTED
A	J2-2 =	27V	
B	J2-2 =	5.05V	
13.20			Closed-Loop (SINGLE SYSTEM)
13.30			START-UP AND SHUTDOWN OPERATIONS
A	J2-1 =	27V	
	J2-2 =	27V	
	J2-3 =	27V	
	J2-4 =	27.4V	
	J2-5 =	27V	
	J2-6 =	27V	
	J2-7 =	27V	
	J2-8 =	27V	
	J2-10 =	11.6V	
	J2-11 =	11.6V	

FORM 1349 R/S (12/62) PRECEDING PAGE NO. _____

FOLLOWING
PAGE NO.

A.F. SIG.

NO: 22022

W.O. 54805

EXPERIMENTAL LABORATORY TEST RECORD

MODEL NO. 51527-000 SERIAL NO. 104

COG. ENGR. *Harriet*

ROTOR NO. STATOR NO.

DATE OF TEST

6/11/88

TEST LETTER: NO. QP387

TESTED BY R.J. SAVICK

IRISH GRADE

BAR. PRESSURE

M.P. AIR GAP

I.P. AIR GAP

TITLE:

ACCEPTANCE TEST PROCEDURE 17-510131

PAGE 3 OF 9

PARA. NO.

TIME

AMB. TEMP.

13.1

START-UP AND SHUT-DOWN OPERATIONS

B.

TP4 - PWB-3 (H1) 14.2V (5000 RPM)

TP4 - PWB-3 (Low) 0.0V (8000 RPM)

INDICATOR LIGHTS (L1) OUT. (SEE)

PER = 270% SV WITH 5 AMP PER-LOAD.

C.

9000 RPM 2744V 5A PER-LOAD

9000 RPM 2682V 84A LOAD

9000 RPM 2672V 167A LOAD

9000 RPM 2636V 210A LOAD

D.

17500 RPM 2687V 84A LOAD

17500 RPM 2673V 167A LOAD

17500 RPM 2671V 208A LOAD

E.

14000 RPM 2660V 84A LOAD

16000 RPM 2676V 167A LOAD

14000 RPM 2673V 208A LOAD

W.O. 54805

EXPERIMENTAL LABORATORY: TEST RECORD

COG. ENGR. Harma7

MODEL NO. 51527-000 SERIAL NO. 104

ROTOR NO.

STATION NO.

DATE OF TEST

6/12/88

TEST LETTER: NO. QP 387

TESTED BY P. J. SAVIUK

BRUSH GRADE

BAR. PRESSURE

M.P. AIR GAP

I.P. AIR GAP

DATE: ACCEPTANCE TEST PROCEDURE 17-510121

PAGE 5 of 9

PARA. NO.	TIME	AMG. TEMP
--------------	------	--------------

TIME	ANG. TEMP.
10:00	100
10:15	100
10:30	100
10:45	100
11:00	100
11:15	100
11:30	100
11:45	100
12:00	100
12:15	100
12:30	100
12:45	100
13:00	100
13:15	100
13:30	100
13:45	100
14:00	100
14:15	100
14:30	100
14:45	100
15:00	100
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15:30	100
15:45	100
16:00	100
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21:30	100
21:45	100
22:00	100
22:15	100
22:30	100
22:45	100
23:00	100
23:15	100
23:30	100
23:45	100
24:00	100

4321

START-UP AND SHUT-DOWN OPERATIONS

i

TPV-PWB-3	H ₂ SPTK	Handwritten operation.
-----------	---------------------	------------------------

TP-1-PW8-3

TPV-PUB-3	Low	Static	1
-----------	-----	--------	---

Sensitization Specimen Below Spec 4-500

TP4. Pub-3 switches to HHS STATE.

2 SEC. 7-0.8

TP1-PWS switches to Low: S/P/T

LIES ARE "OM"	P.O.R.	VOLTAGE	0.0 V
---------------	--------	---------	-------

Overall Protective Test

A.

A.	1600 RPM	84A,	265.5 V
----	----------	------	---------

TP3	PWB1	"LOW" STATE
-----	------	-------------

22-3	22
------	----

4. The "DEF"

6.

B.	output	290VDC
----	--------	--------

TP-2 Pub.

TP-2	PW81	SWITZELER "Hi"	momentarily
------	------	----------------	-------------

552611708

GERMANY DE-SUBSISTED

6/17/55	ON
---------	----

$V_2 - 3 = 5.06 \text{ V}$

www.dunip.co.uk

EXPERIMENTAL LABORATORY, TEST RECORD

COG. ENGR. Harold T.

W.O. 54805

MODEL NO. 51527-0011 SERIAL NO. 184

ROTOR NO. STATOR NO.

DATE OF TEST

TEST LETTER: NO. QP387 TESTED BY R. J. Sarnick

RUSH GRADE

BAR. PRESSURE

M.P. AIR GAP

I.P. AIR GAP

DATE: ACCEPTANCE TEST PROCEDURE 17-510121

[illegible]

1323. UNDER VOLTAGE PROTECTION TEST

D.

269.414

normal pressure

1. The "EE"

IT9-7 A11011 SAME AS STDN A

13.24

RECEIVED
FAULT PROTECTION
TEST

A

17000	Bv	281
-------	----	-----

2015-11-27

JKZ-5-2V

$$T_2 // = 8.12$$

LITES ARE OFF

B

125A CALLT re 1000/1000 1000/1000

SYSTEM TRIP

$C_{20} = 0.10 =$	$n = 10$	$n = 10$
-------------------	----------	----------

79	5	511
----	---	-----

$$T_2 - V_1 = 5.1 \text{ K}$$

LETTERS ARE 'OK'

FORM 1349 2/3 11/2/82

CONCLUSION

A.F. SIG.

NO: 2222

55

COG. ENGR. HARMA T
 ROTOR NO. STATOR NO.

EXPERIMENTAL LABORATOR. TEST RECORD

W.O. 54805

MODEL NO. 51517-060
SERIAL NO. 104

ROTOR NO. STATOR NO.

DATE OF TEST 6/12/88 TEST LETTER: NO. 0P387 TESTED BY R.J. SAKIUK

RUSH GRADE

BAR. PRESSURE

M.P. AIR GAP

I.P. AIR GAP

171 F.

PTANCE TEST PRICEDUR 17-510121

PAGE 8 of 9

PARA. NO.	TIME	ANS. TEMS
1	10	10
2	10	10
3	10	10
4	10	10
5	10	10
6	10	10
7	10	10
8	10	10
9	10	10
10	10	10
11	10	10
12	10	10
13	10	10
14	10	10
15	10	10
16	10	10
17	10	10
18	10	10
19	10	10
20	10	10
21	10	10
22	10	10
23	10	10
24	10	10
25	10	10
26	10	10
27	10	10
28	10	10
29	10	10
30	10	10
31	10	10
32	10	10
33	10	10
34	10	10
35	10	10
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37	10	10
38	10	10
39	10	10
40	10	10
41	10	10
42	10	10
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86	10	10
87	10	10
88	10	10
89	10	10
90	10	10
91	10	10
92	10	10
93	10	10
94	10	10
95	10	10
96	10	10
97	10	10
98	10	10
99	10	10
100	10	10

[illegible]

2

SYSTEM WILL NOT RESET INTO FAULT
LITER "ON"
JUL-5 APR 11 SAME AS STEP B.

2

	Fault Removal And System Reset
	Nuclear Operation
	LITTS DEF "
JT-5 AND 11	SAME AS STEP A.

1322.5

OVERCURRENT PROTECTION TEST

A

16000 RPM	1676	270.2 VDC	
J2-6	- 22K	J2-11	81V
PAR	270.2 VDC		
LITAC	OFF	"OFF"	

3

LOW INCREASE IN FLIGHT THAN 250A AND APPROX
360A FOR 7 SECONDS, GENERATOR DE EXERCISE
LITTS "ON"
53-6 APR 11 = 5.1V

٧

OVERLAP SEASON. RESET, NORMAL OPERATING.

2608
1825

COG. ENGR. HARMA T

ROTOR NO. STATOR NO.

EXPERIMENTAL LABORATORY TEST RECORD

MODEL NO. 51527-000

6/12/88 TEST LETTER: NO. PP 387 TESTED BY R. J. SAVIUK

DATE OF TEST 6/12/88

BRUSH GRADE

BAR. PRESSURE

M P AIR GAP

IP AIR GAP

TIME: ACCEPTANCE TEST PROCEDURE 17-5/0121

PAGE 9 of 9

[illegible]

43.26

GENERATOR WARMING AND DISCONNECT TEST

SIMULATED TEST.	POWER RESISTOR USED IN PLACE OF DISC CONT.
-----------------	--

A.

16000	272100
-------	--------

J2-10	8.1
-------	-----

13-11-81

lites are "off"

RES. VOLTAGE "LOW" STATE

B

PIN 13	- J1	5	1000	EN TO	600	(PIN 13 OF 600)
--------	------	---	------	-------	-----	-----------------

RES	VOLTAGE	11"	STATE
-----	---------	-----	-------

J2-10 =	11.50
---------	-------

$$I_2 V = 5.14$$

L-1785 ALL "ON"

2

Deane Martin p. 12-11

RESET	5 V5 / 5 M	OPERATION NORMAL
-------	------------	------------------

2

open Ti-curve

T2-14 - 14.5V.

OTHER INDICATIONS: NO PAIN

CONCLUSIONS

All tests performed on the generating system demonstrated that, on the whole, the system met or exceeded the requirements set down in the Navy specification. It was also demonstrated that the requirements of MIL-STD-704D and AS-1831 could also be met.

The exceptions in performance experienced are correctable by changes and additions to the generator control unit circuitry. The baseline electrical design approach of the generator is sound and would require refinements to reduce generator weight. The mechanical design approach was also demonstrated to be sound. It might be refined for weight reduction by the use of spray oil cooling in lieu of the conduction cooling used, however, some loss in efficiency could result due to the expected attendant increase in rotor oil windage losses at high rotor speeds.

Based on the results of this development and test program, which is admittedly considerably below the state-of-the-art, it is readily concluded that no insurmountable problems should be faced if baseline specifications were somewhat tightened, e.g. MIL-STD-704D and the proposed MIL-STD-704E.

References

- 1) NADC-60-TS-7803 Generator System, 270 volts, Direct Current, Oil Cooled, Aircraft, General Specification for, 5 January 1978.
- 2) MIL-STD-704D, Aircraft Electric Power Characteristics, 30 September 1980.
- 3) MIL-STD-704E, Aircraft Electric Power Characteristics, Preliminary.
- 4) AS-1881 Characteristics and Utilization of Aircraft High Voltage Direct Current Electric Power, April, 1986.

APPENDIX

**PHOTOGRAPHS
AND
DRAWINGS**

EW/O. 53

DATE OF TEST

BRUSH GRAD

TITLE: A

PAGE NO.

1328

1328

C

D

A

B

C

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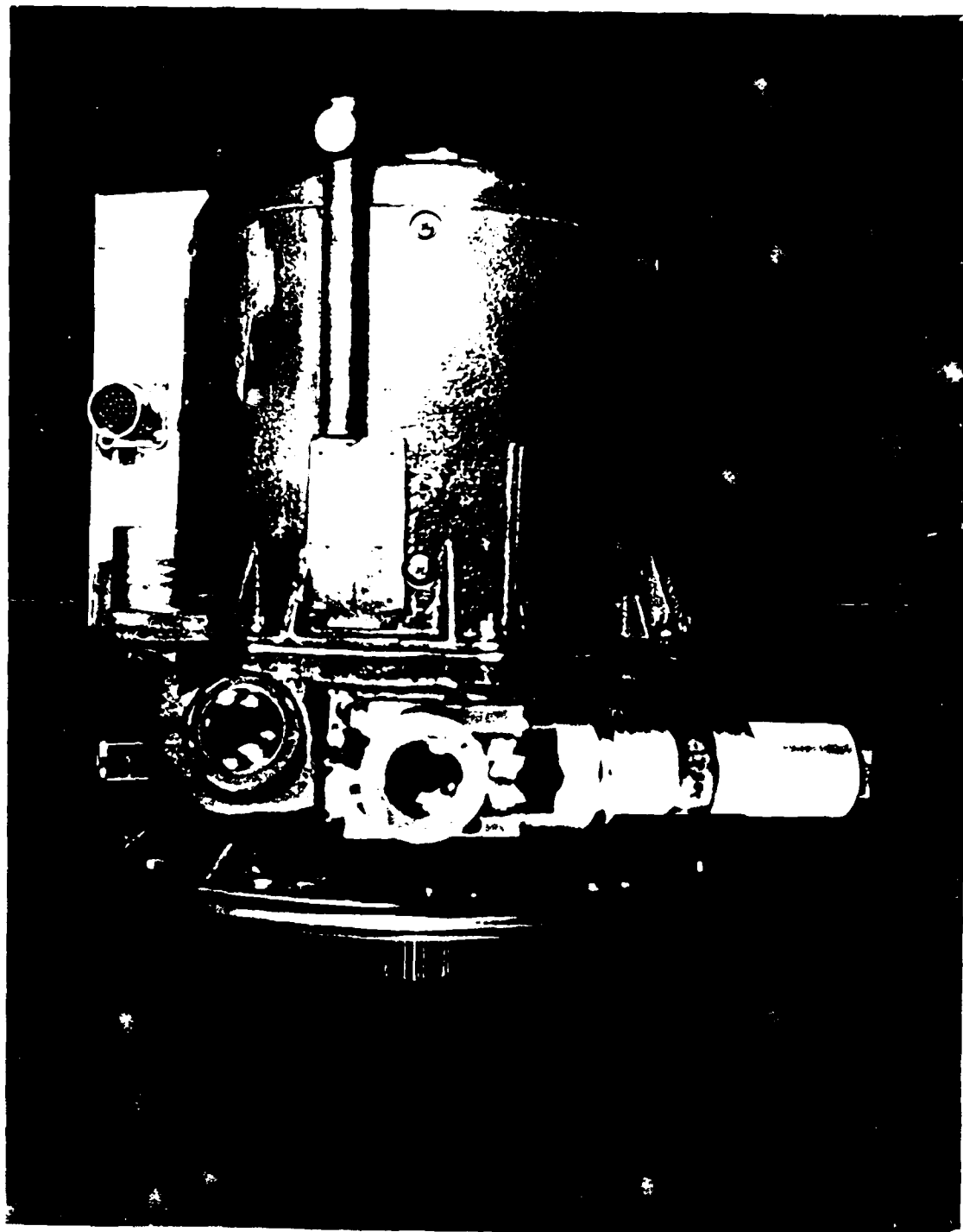
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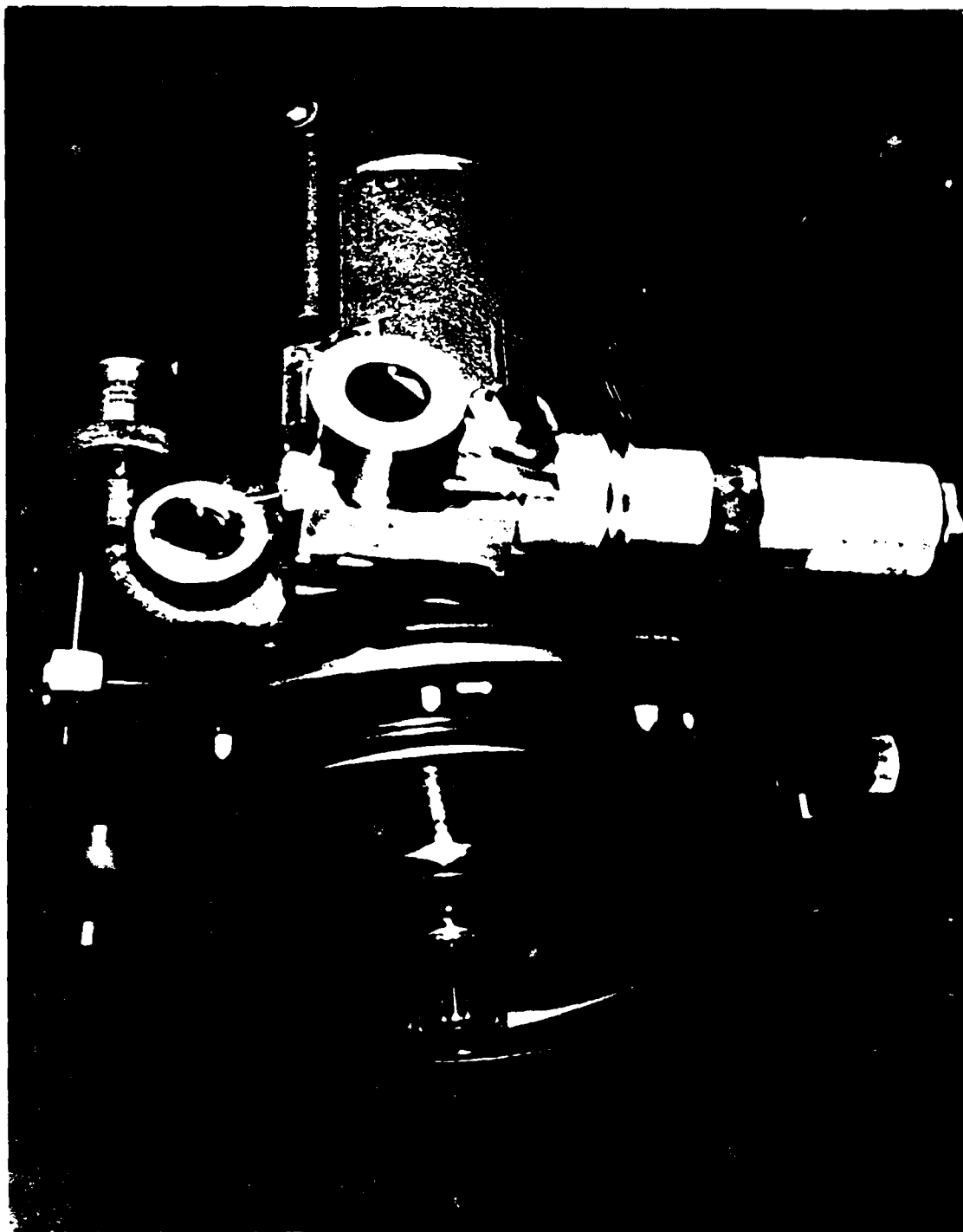
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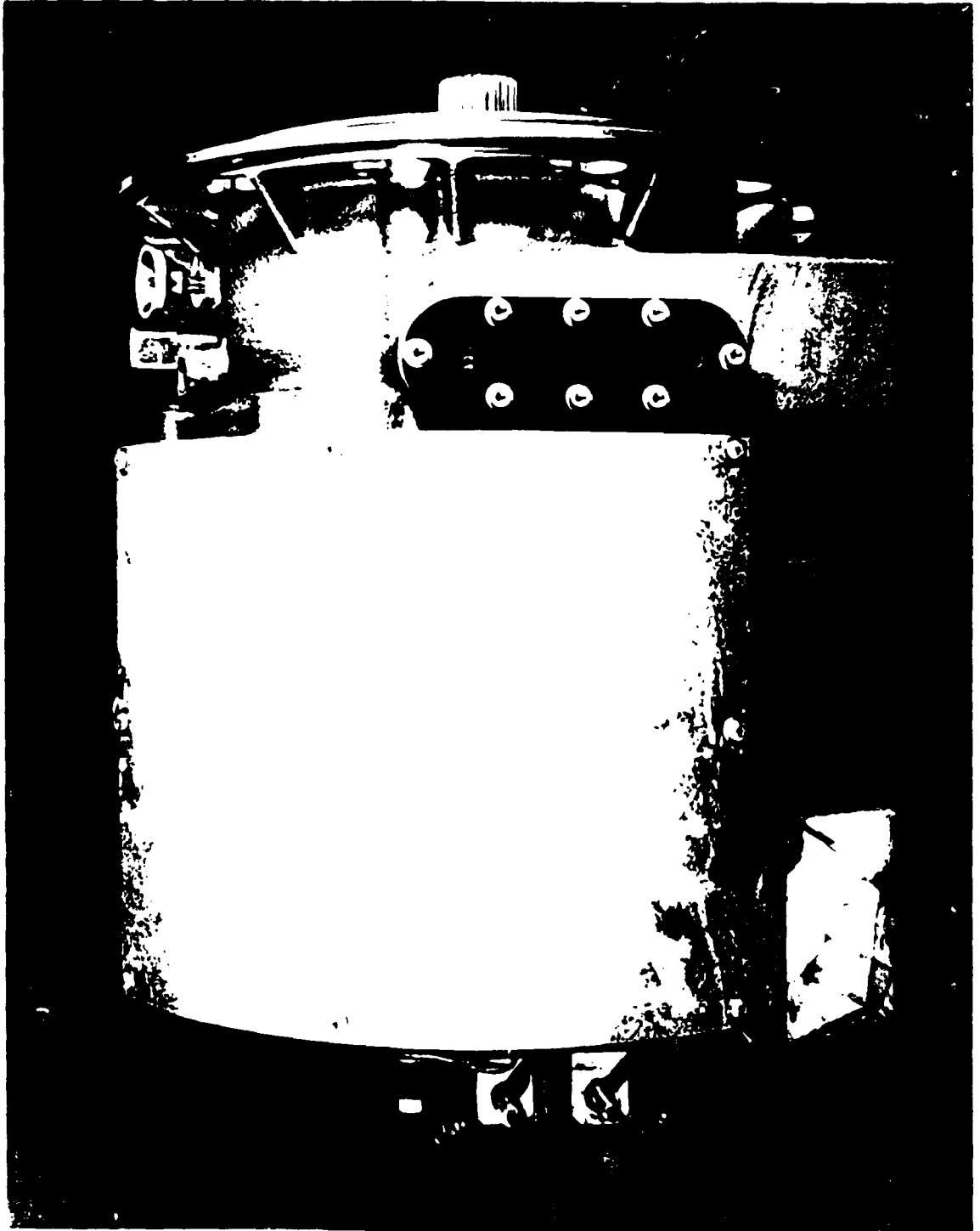
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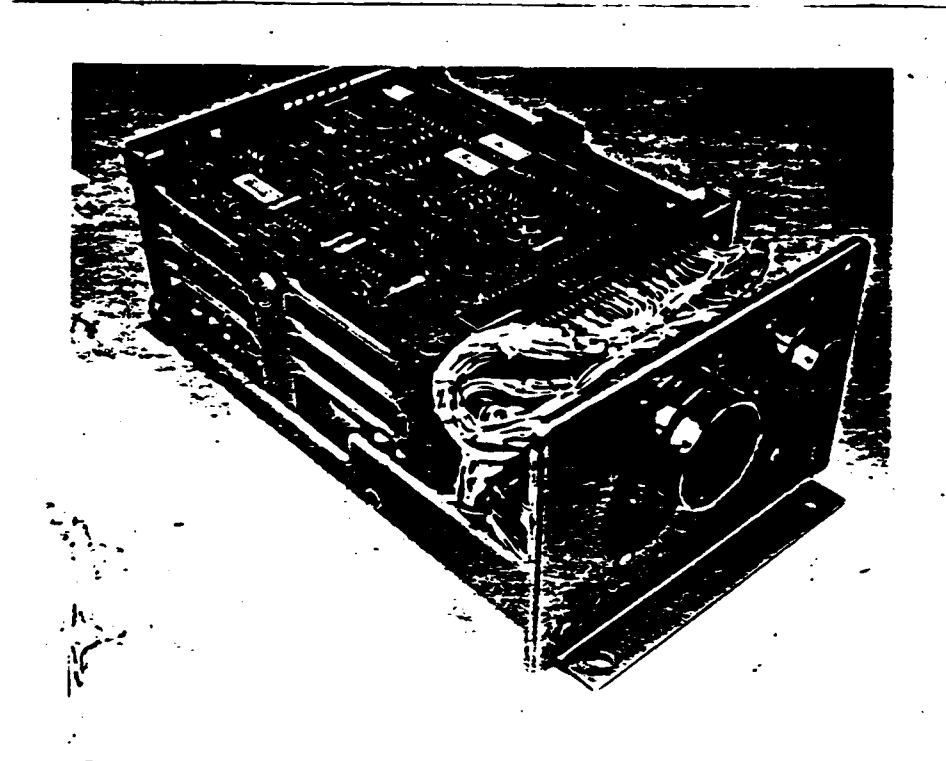
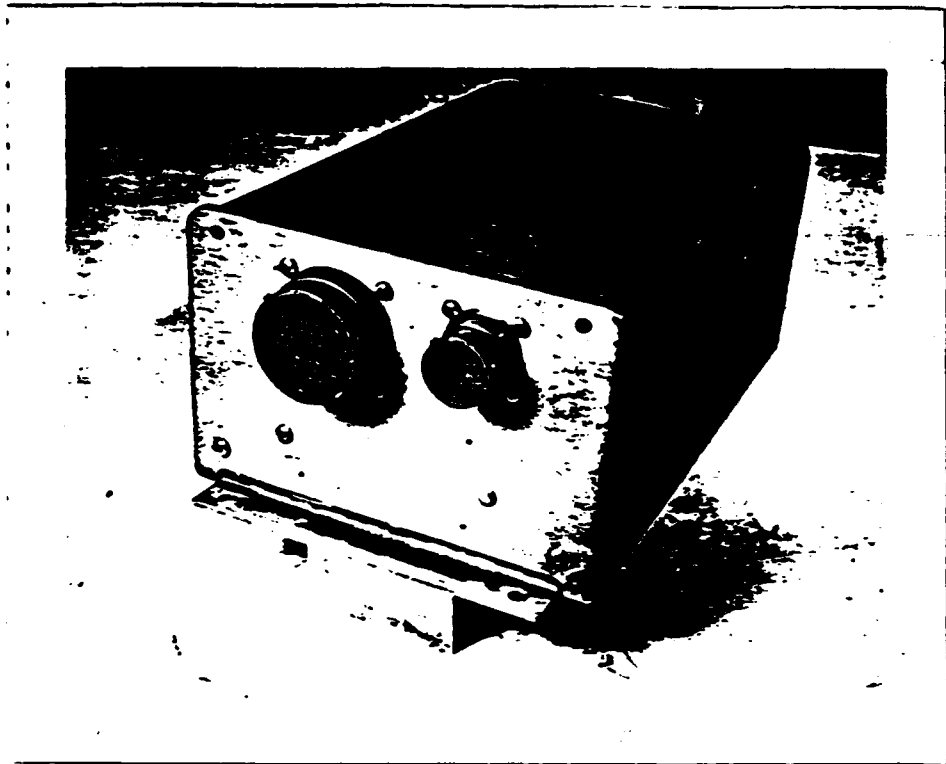
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1328

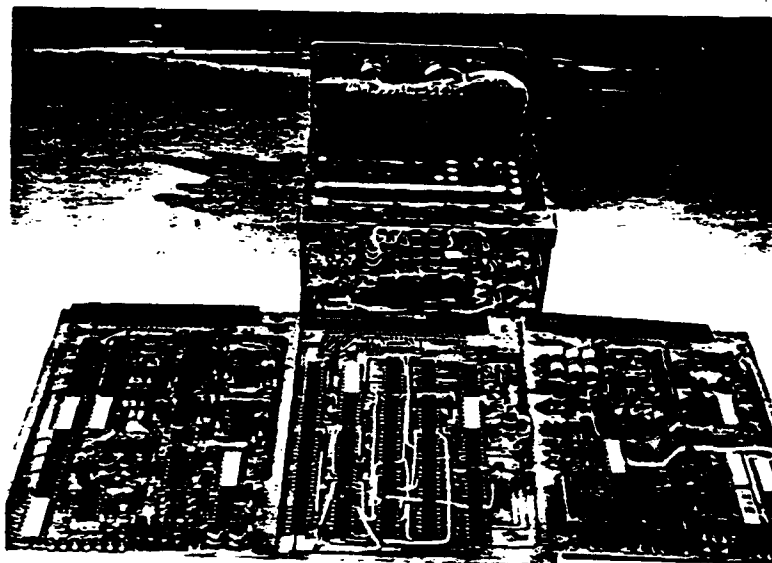
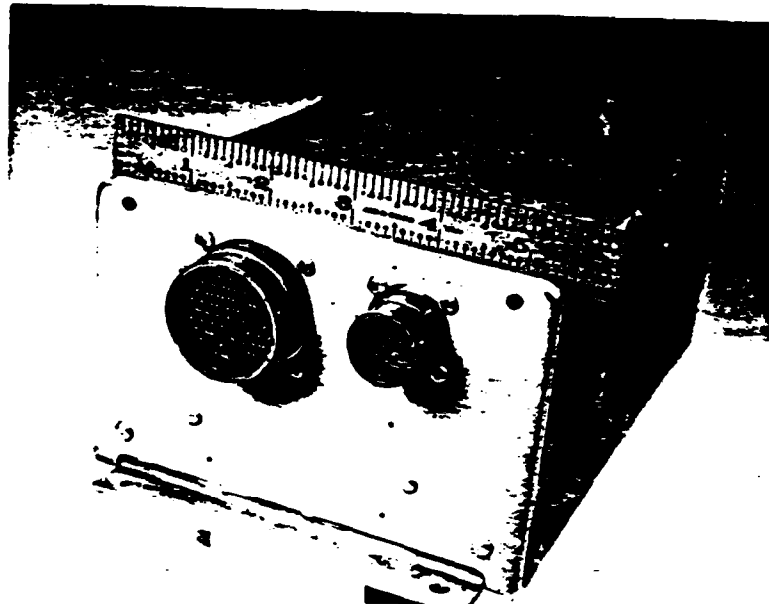






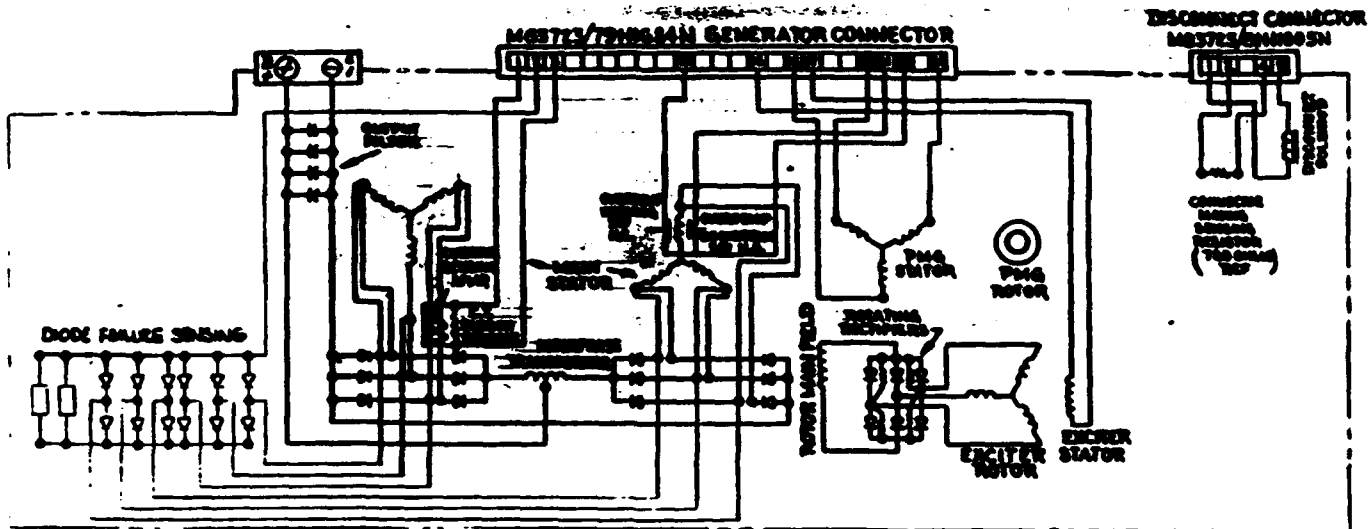


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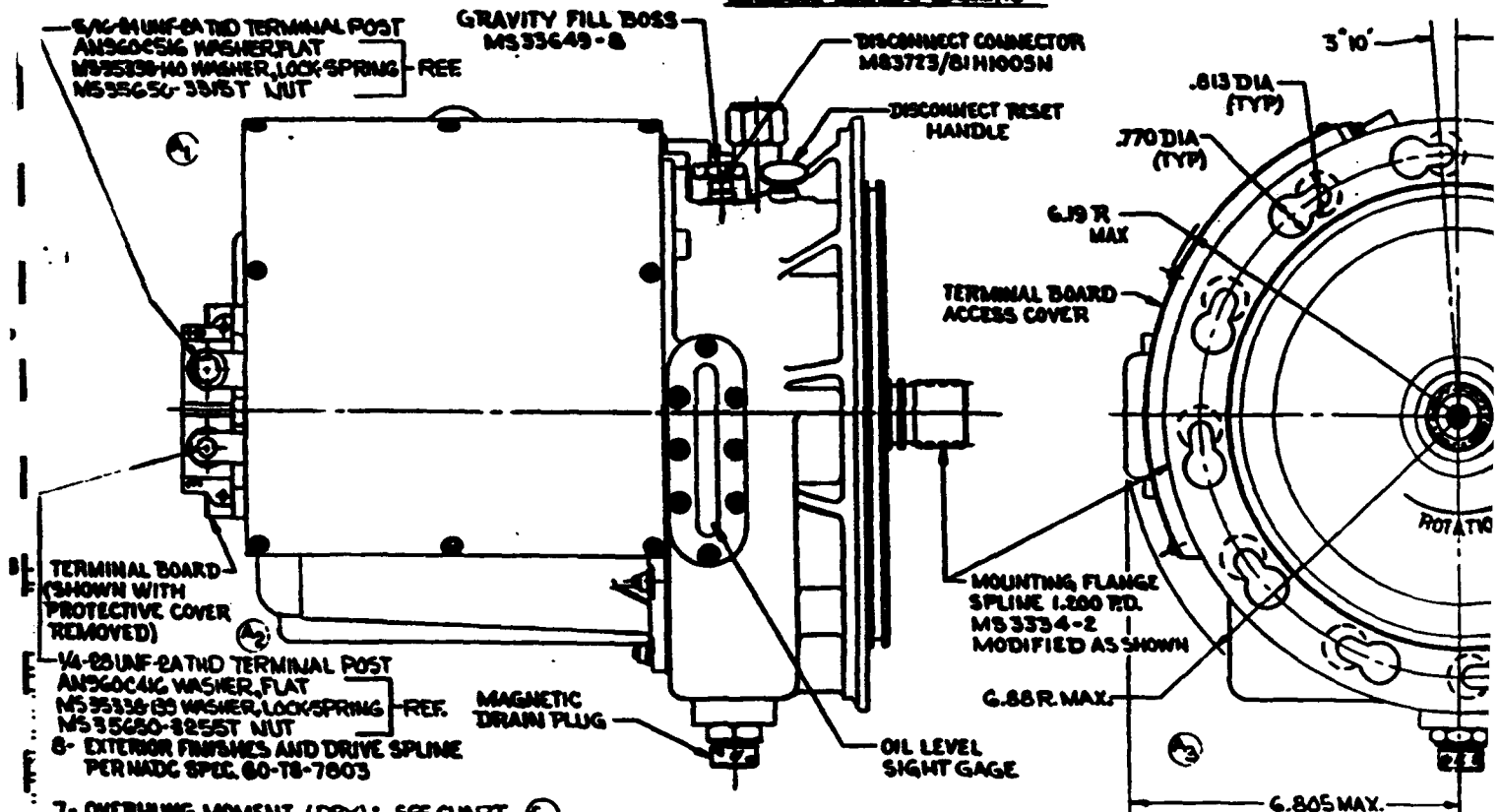


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GENERATOR PARTS 32-54517C



7- OVERHUNG MOMENT (DRY): SEE CHART (C)

6- WEIGHT (DRY): SEE CHART (C)

5- RATED SPEED: 9000 TO 18000 RPM
OVERSPEED: 19800 RPM
PROOF SPEED: 21600 RPM

4- RATING: 45 KW, 270VDC, 166.7 AMPS.

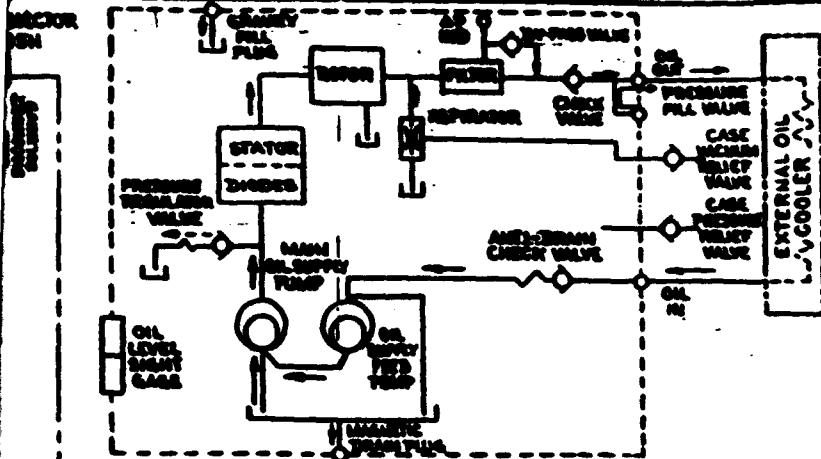
3- OIL-COOLED WITH INTEGRAL OIL PUMPS
PER NADG SPEC 60-TS-7803.
COOLING OIL TO BE PROVIDED TO
OIL INLET PORT OF GENERATOR

2- SEE ENG SPEC 60-TS-7803 APPENDIX

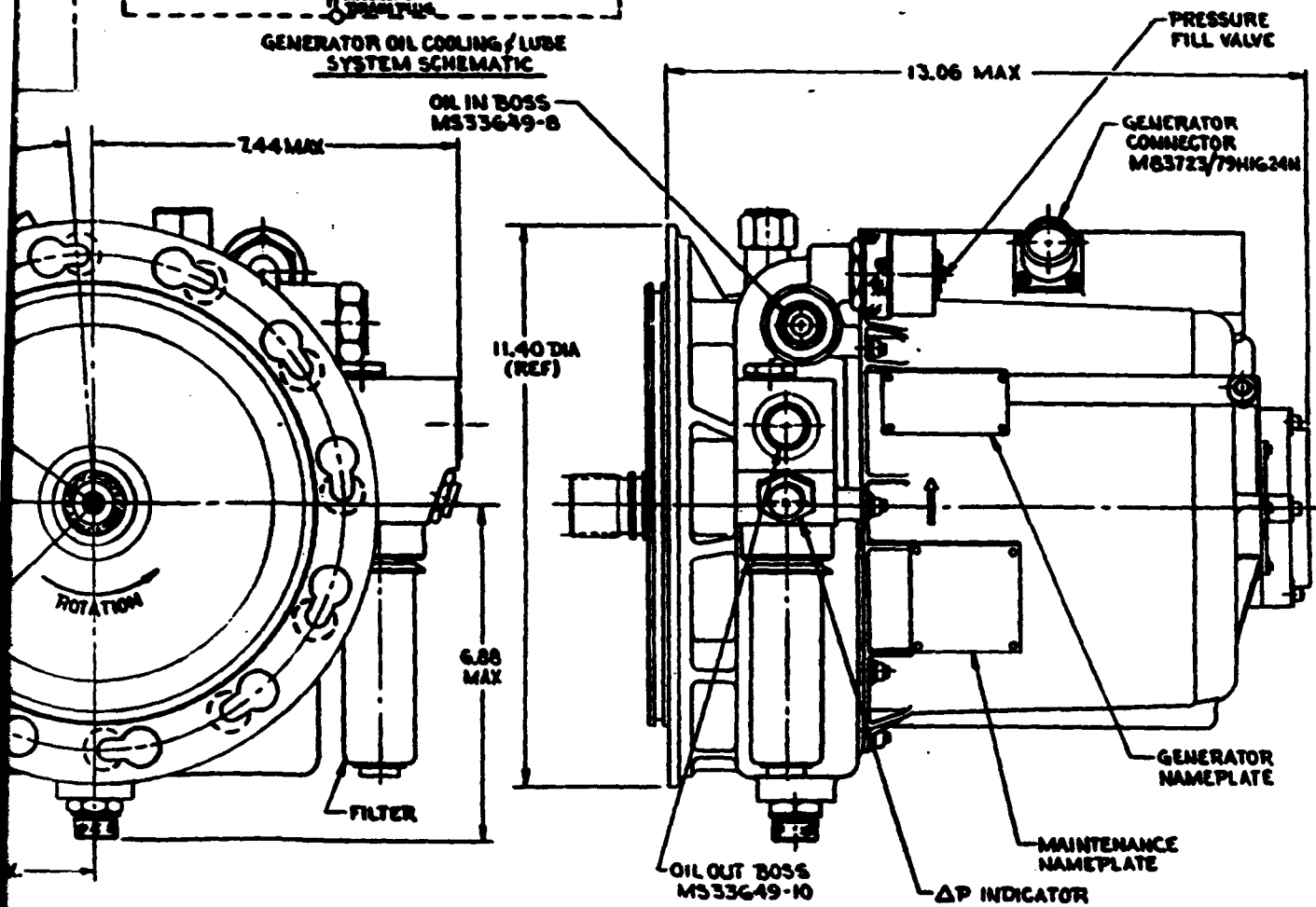
1- SEE ENG SPEC 60-TS-7803 APPENDIX

NOTES:

(C)	469.4
(C)	451.9
NOTE 7	
100 M. AHS. W	



REVISIONS				
REV	DESCRIPTION	DATE	APPROVED	
A	REVISED PER ECH 01018	1-2-81	M. P. DILLON	
B	ADDED DDDZ FAULT SIGNAL TO ECH 01018	1-2-81	M. P. DILLON	
C	REVISED PER ECH 016075	1-2-81	M. P. DILLON	



DIMENSIONS SHOWN ARE FOR INSTALLATION PURPOSES ONLY. DIMENSIONS WHICH ARE SPECIFIED AS MAXIMUM OR MINIMUM OR ARE TOLERANCES, WILL BE MET. ALL OTHER DIMENSIONS ARE FOR REFERENCE ONLY.

REV OR FOR NO.	QTY REQ	CODE IDENT	PART NO.	DESCRIPTION
----------------	---------	------------	----------	-------------

PARTS LIST

Lucas Aerospace
Power Equipment Corporation
Aurora, Ohio 44202

**GENERATOR.
270V, D.C. BRUSHLESS,
SELF OIL COOLED**

31485 305270000/0001

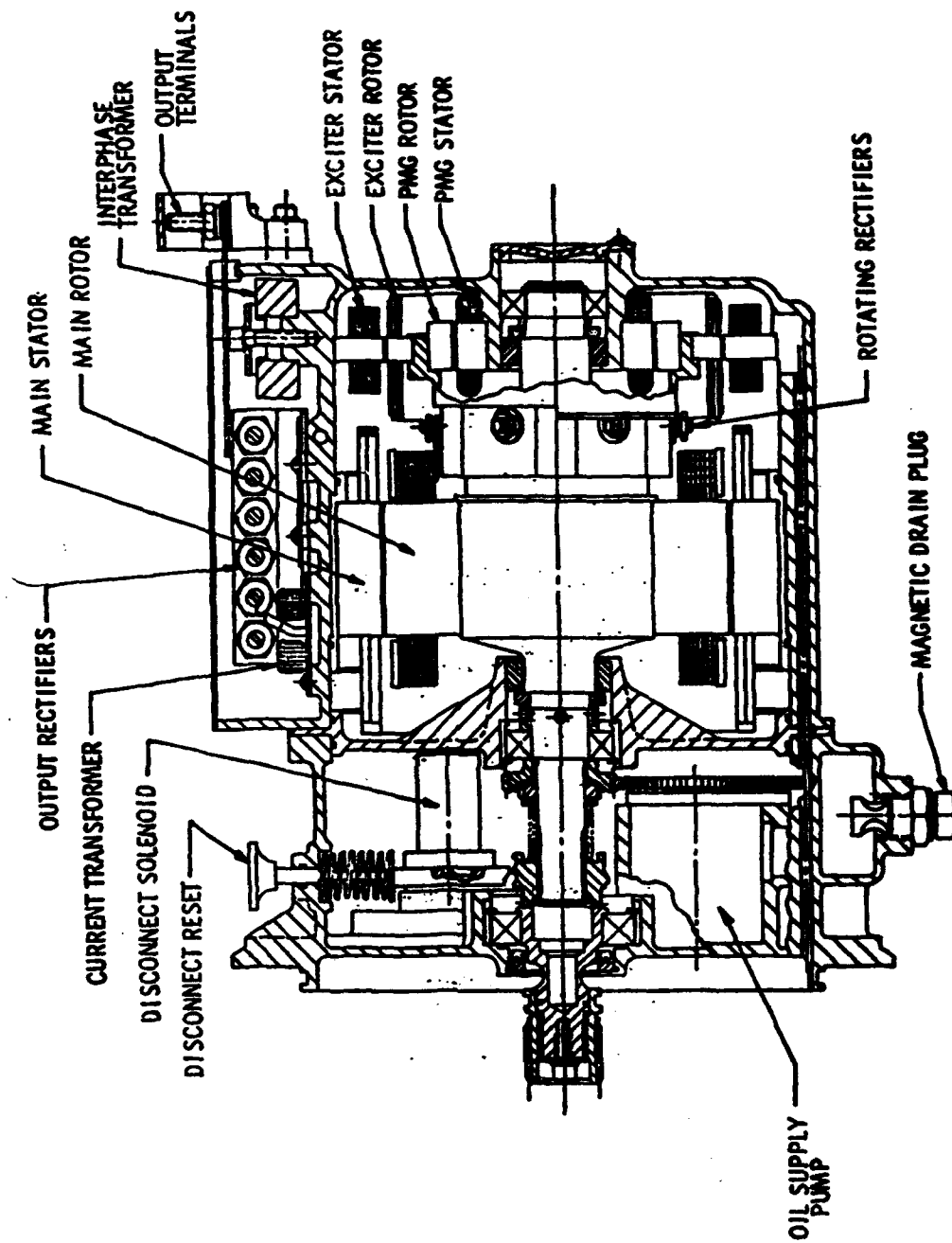
469.4	74.6	30527-001	305270001
451.9	72.0	30521-000	305270000
NOTE 7 DALM, INCHES	NOTE 6 WT. LBS.	MODEL NO.	OUTLINE NO.

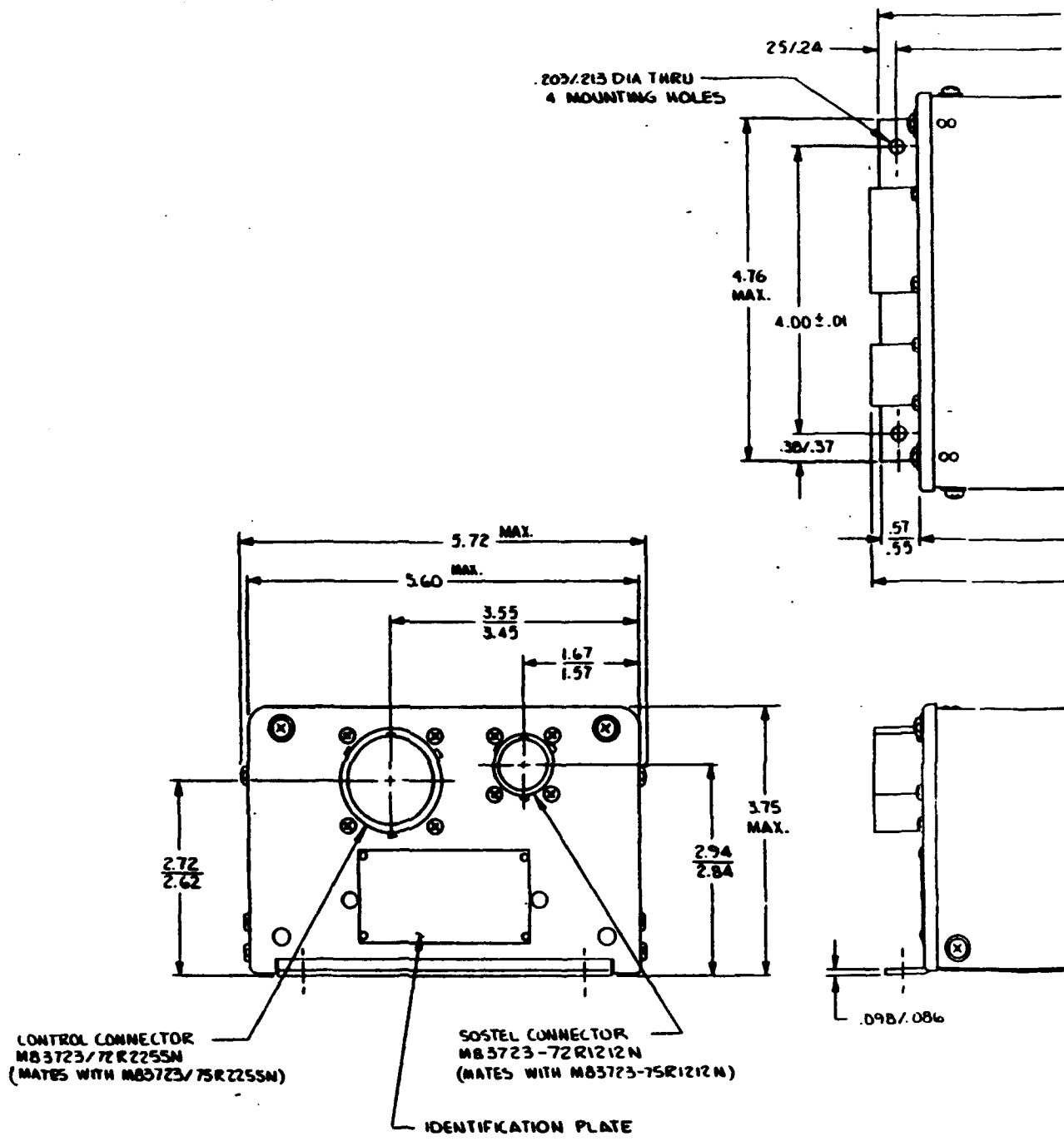
(2)

Lucas Aerospace

Lucas Aerospace Power Equipment Corporation

GENERATOR/ADAPTER CUTAWAY





- 3 - WEIGHT: 60 LBS. MAX.
- 2 - ~~3RD ENG STD 16 001001 APPLIES~~
- 1 - ~~3RD ENG STD 16 011001 APPLIES~~

NOTES:

(D)

100002515

3

4

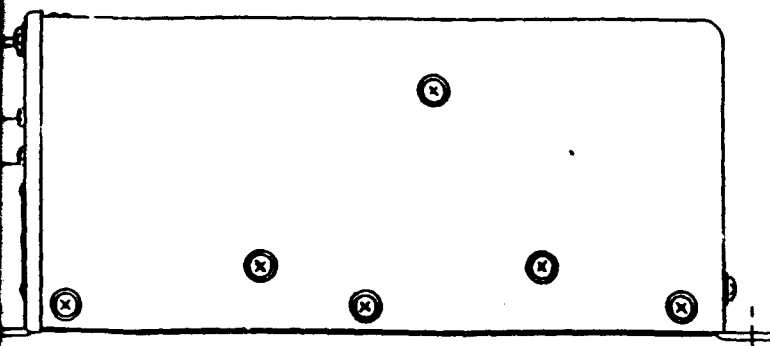
REVISIONS				
REV	BY	DESCRIPTION	DATE	APPROVED
A		LINKED OUT NOTE 1 & 2 REMOVED NOTE 3 WAS S.L.S.	8-24-74	W. J. [Signature]

9.63 MAX.

9.120 ± .040

8.50 MAX.

9.80 MAX.



086

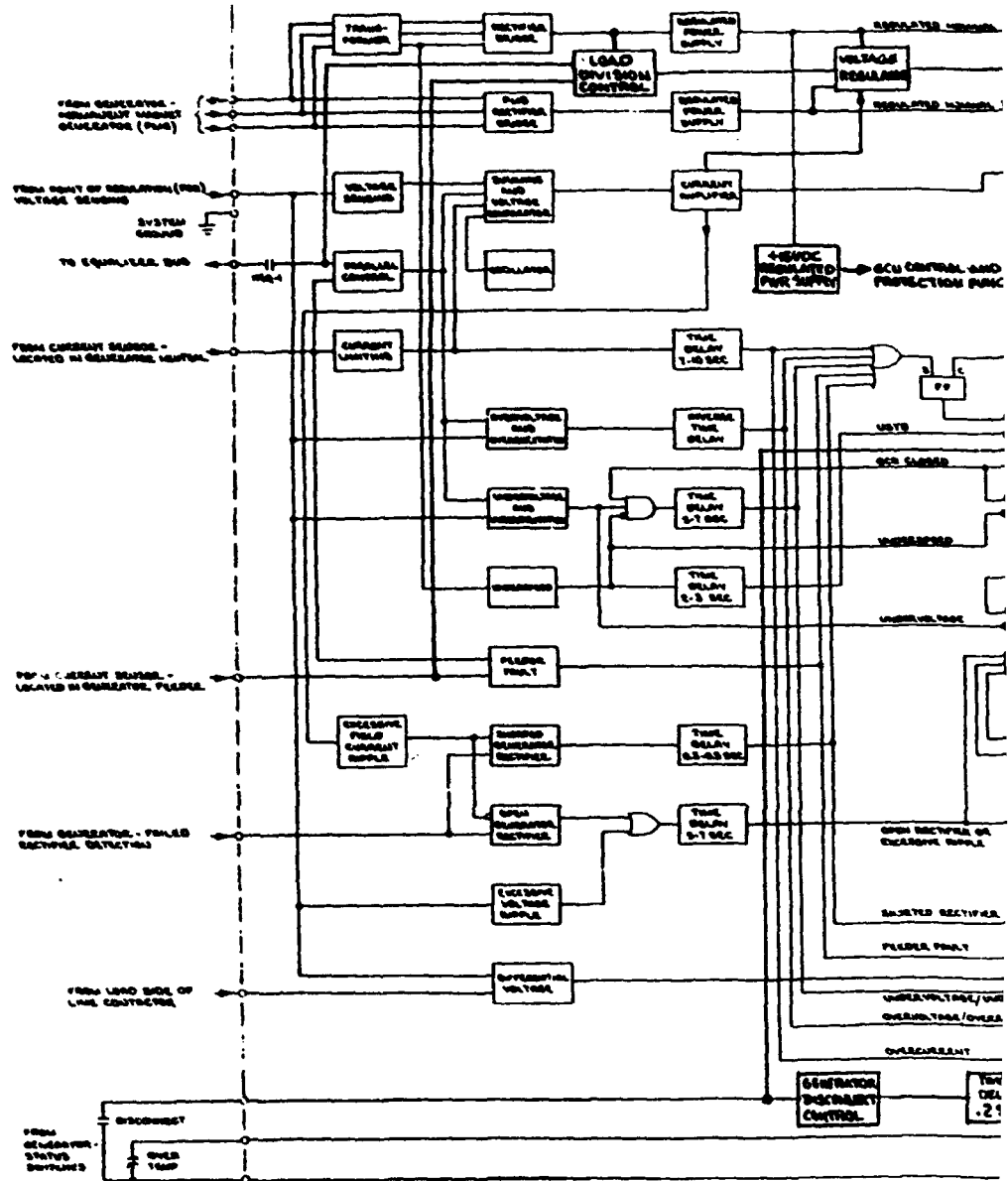
515270000

ITEM OR FIND NO.	QTY REQ	CODE IDENT	PART NO.	DESCRIPTION
PARTS LIST				
<small>UNLESS OTHERWISE SPECIFIED, DIMENSIONS ARE IN INCHES. TOLERANCE ON: DECIMALS .010 ANGLES ± 0° 30'</small> <small>DO NOT SCALE THIS DRAWING</small> <small>MATERIAL</small>			<small>DRAWN BY</small> S. S. ZELDENYAK <small>DATE</small> 4-15-80 <small>CHECKED BY</small> <small>MATL APVD</small> <small>DATE</small> <small>MFG ENGR</small> <small>DATE</small> <small>PROJECT ENGR</small> [Signature] <small>DATE</small> 4-26-80 <small>CONTRACT NO.</small>	
<small>Lucas Aerospace Power Equipment Corporation Aurora, Ohio 44202</small>			GENERATOR CONTROL UNIT, FOR BRUSHLESS 270 VDC GENERATOR	
			<small>REF. FROM NO.</small> D 31435 <small>QTY</small> 515270000 <small>SCALE</small> 1/1 <small>SHEET</small> 1 OF 1	

NEXT ASSY	USED ON
PART APPLICATION	

(2)

THIS DOCUMENT CONTAINS INFORMATION PROPRIETARY TO
 LASS HONEY INC AND IS PROVIDED UPON THE EXPRESS CON-
 DITION THAT THE INFORMATION CONTAINED HEREIN WILL NOT
 BE USED FOR REPRODUCING OR DISSEMINATING IN ANY MANNER
 OR BY ANY MEANS WITHOUT THE WRITTEN PERMISSION OF
 LASS HONEY INC. POWER SYSTEMS DIVISION.

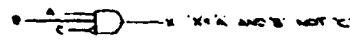


4. THE FLIP-FLOP STABLE FUNCTION
 A PULSE SIGNAL RECEIVED AT THE STABLE
 INPUT AND REMOVED WILL CAUSE THE FF
 TO PROVIDE A CONTINUOUS OUTPUT, THE FF
 OUTPUT IS REMOVED BY APPLYING A PULSE
 SIGNAL AT THE CLEAR INPUT.

5. LOGIC SYMBOLS USED ARE IN ACCORDANCE
 WITH MIL STD-883C
 2 - RED AND STD 16-00000-APPLIES
 1 - RED AND STD 16-00000-APPLIES

NOTES:

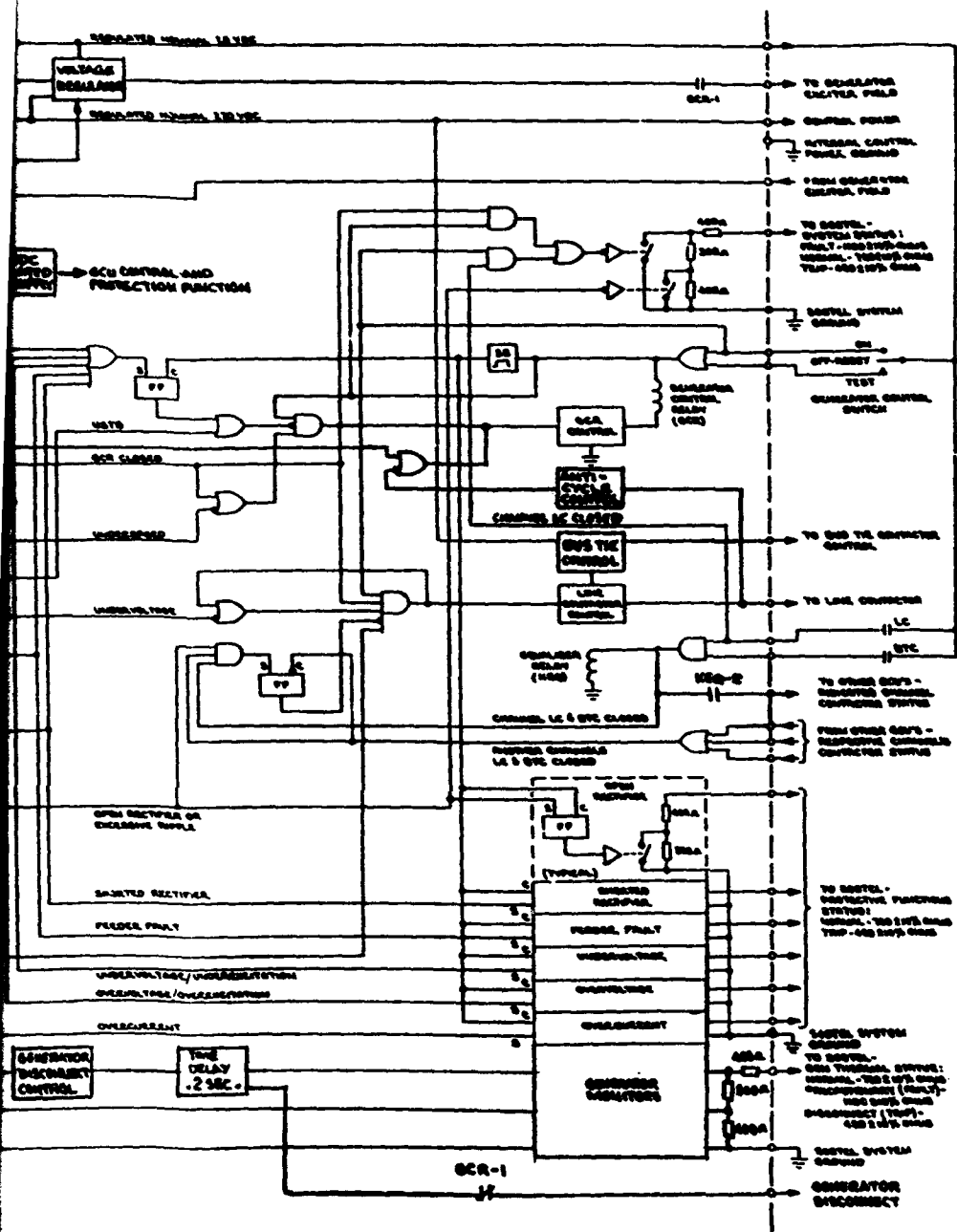
3. LOGIC SYMBOLS - A SMALL CIRCLE AT
 THE INPUT TO ANY LOGIC ELEMENT
 INDICATES THAT THE PRESENCE OF
 THE SIGNAL INHIBITS THE FUNCTION.
 AN INPUT TO ANY LOGIC ELEMENT WITH
 NO SMALL CIRCLE INDICATES THAT THE
 SIGNAL ACTIVATES THE FUNCTION.
 EXAMPLE:



LEGEND

- BTC BUS TIE CONTACTOR
- FF FLIP-FLOP
- GCR GENERATOR CONTROL
- GCU GENERATOR CONTROL
- HSR EQUALIZER RELAY
- LC LINE CONTACTOR
- PWG PERMANENT WAGNET
- POS POINT OF REGULATION
- SS SHUT-DOWN
- TEMP TEMPERATURE
- USTO UNDERSPREAD THRESHOLD

(1)

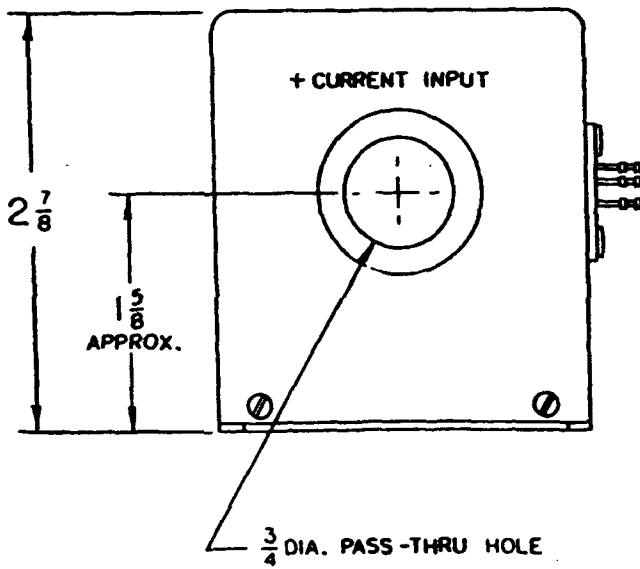
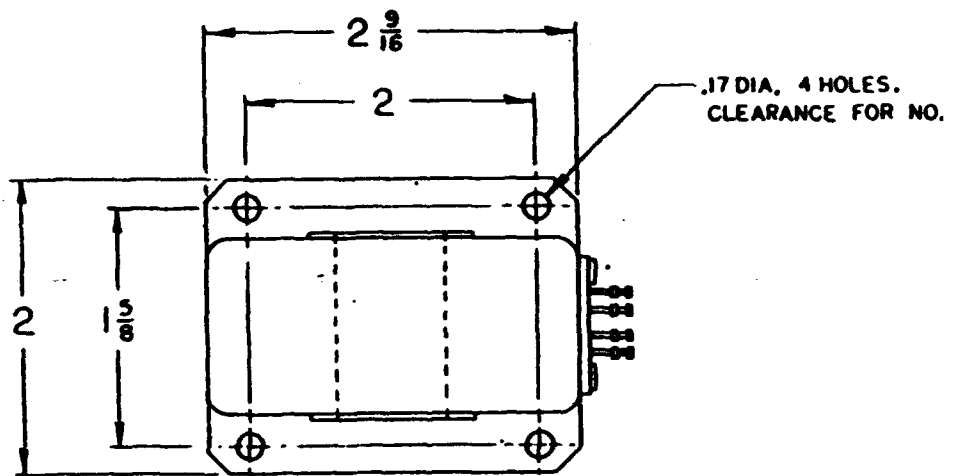


LEGEND

BUS TIE CONTACTOR
BUS-STOP
GENERATOR CONTROL RELAY
GENERATOR CONTROL UNIT
EQUALIZER RELAY
LINE CONTACTOR
PERMANENT MAGNET GENERATOR
POINT OF REGULATION
SINGLE-SHOT
TEMPERATURE
UNDER-SPEED TIME DELAY

[illegible]

(2)



1 - WEIGHT: 1.7 lbs
NOTE(S):

—	—
NEXT ASSY	USED ON
FIRST APPLICATION	

(1)

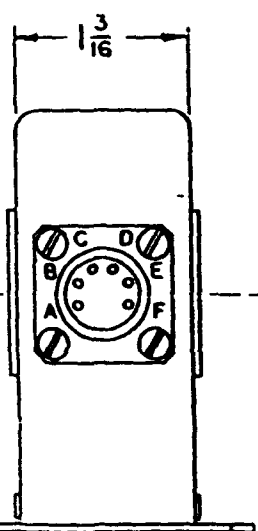
000012505

ON
DWG

REVISIONS

REV	DESCRIPTION	DATE	APPROVED
A	ADDED NOTE 1	ZELENAR 8-27-91	<i>[Signature]</i> 8/27/91

NO. 8 SCREW.



DWG NO. 505270000

REV Δ

FILES

E

P

↑

UNLESS OTHERWISE SPECIFIED
DIMENSIONS ARE IN INCHES
~~TERMINALS ARE 0.031 INCHES
WIDE AND 0.031 INCHES HIGH~~

DO NOT SCALE THIS DRAWING

MATERIAL:
AMERICAN AEROSPACE
CONTROLS, INC

SERIES 934

DRAWN BY
S.J. ZELENAR DATE
8 FEB 88

CHECKED BY DATE

MATL APVD DATE

MPG ENGR DATE

PROJECT ENGR (MECH/ELEC) DATE
[Signature] *2-8-88*

CONTRACT NO.



Lucas Aerospace
Power Equipment Corporation
Aurora, Ohio 44202

OUTLINE DRAWING,
D.C. CURRENT SENSOR

SIZE FSCM NO.
B 31435

DWG. NO.
505270000

SCALE *NONE*

SHEET 1 OF 1

AF N A CUST

PTI
ASSIGNED ☐

(2)